PB-240 060

RADIOLOGICAL HEALTH DATA AND REPORTS. VOLUME 8, NUMBERS 4-6, APRIL-JUNE 1967

Public Health Service
Washington, D. C.

June 1967

DISTRIBUTED BY:

NTIS
National Technical Information Service
U. S. DEPARTMENT OF COMMERCE

BIBLIOGRAPHIC DATA SHEET	**Report No.** RHDR 8 (4-6)	**2.**	PB 240 060

4. Title and Subtitle
Radiological Health Data and Reports
Volume 8, Nos 4-6

5. Report Date
Apr-June 1967

6.

7. Author(s)
None

8. Performing Organization Rept. No.

9. Performing Organization Name and Address
U.S. Department of Health, Education, and Welfare
Public Health Service
Washington, D. C. 20201

10. Project/Task/Work Unit No.

11. Contract/Grant No.

12. Sponsoring Organization Name and Address
U.S. Environmental Protection Agency
Office of Radiation Programs
401 M St., S. W.
Washington, D. C. 20460

13. Type of Report & Period Covered
Final: Apr-June 1967

14.

15. Supplementary Notes

16. Abstracts

Data and interpretation of data on radiation exposure to humans and on radioactivity in milk, water, air, and other environmental media are presented in 24 volumes. For prices of individual issues, see below.

17. Key Words and Document Analysis. 17a. Descriptors

Radiation
Radioactivity
Air
Water
Milk
Food
Human

17b. Identifiers/Open-Ended Terms

Reproduced by
NATIONAL TECHNICAL INFORMATION SERVICE
US Department of Commerce
Springfield, VA. 22151

PRICES SUBJECT TO CHANGE

17c. COSATI Field/Group

18. Availability Statement Release unlimited	**19. Security Class (This Report)** UNCLASSIFIED	**21. No. of Pages** 173
	20. Security Class (This Page) UNCLASSIFIED	**22. Price** PC/MF 6.25/2.25

RADIOLOGICAL HEALTH DATA AND REPORTS

Volume 8, Number 4, April 1967

In August 1959, the President directed the Secretary of Health, Education, and Welfare, to intensify Departmental activities in the field of radiological health. The Department was assigned responsibility within the Executive Branch for the collation, analysis, and interpretation of data on environmental radiation levels such as natural background, radiography, medical and industrial uses of isotopes and X rays, and fallout. The Department delegated this responsibility to the National Center for Radiological Health, Public Health Service.

***Radiological Health Data and Reports*, a monthly publication of the Public Health Service, includes data and reports provided to the National Center for Radiological Health by Federal agencies, State health departments, and foreign governmental agencies. Pertinent original data and interpretive manuscripts are invited from investigators.**

The Federal agencies listed below appoint their representatives to a Board of Editorial Advisors. Members of the Board advise on general publications policy; secure appropriate data and manuscripts from their agencies; and review those contents which relate to the special functions of their agencies.

Department of Defense
Department of Agriculture
Department of Commerce
Department of Health, Education, and Welfare
Atomic Energy Commission

CONTENTS

REPORTS

Page

Plutonium-239 in Total Diet and Milk 191
P. E. Kauffman and *P. J. Magno*

DATA

SECTION I. MILK AND FOOD 195

National and International Milk Surveillance 196

1. Pasteurized Milk Network, December 1966, *PHS* 196
2. Canadian Milk Network, December 1966 200
3. Pan American Milk Sampling Program, December 1966, *PAHO* and *PHS* 201

State Milk Surveillance Activities 203

1. Oklahoma Milk Network, October–December 1966 203
2. Tennessee Milk Network, July 1965–June 1966 205
3. Texas Milk Network, October–December 1966 207

Food and Diet Surveillance Activities 209

1. Radionuclides in Institutional Diet Samples, July–September 1966, *PHS* 209

CONTENTS—continued

Page

SECTION II. WATER 213

Gross Radioactivity in Surface Waters of the United States October 1966, *FWPCA* 214

SECTION III. AIR AND DEPOSITION 217

Radioactivity in Airborne Particulates and Precipitation 217

1. Radiation Surveillance Network, December 1966, *PHS* 217
2. Canadian Air and Precipitation Monitoring Program, December 1966 221
3. Mexican Air Monitoring Program, December 1966 222
4. Pan American Air Sampling Program, December 1966, *PAHO* and *PHS* 223
5. National Air Sampling Network, October–December and Annual Summary 1966, *PHS* 224

SECTION IV. OTHER DATA 227

Iodine-131 in Bovine Thyroids, July–December 1966, *PHS* 227

Environmental Levels of Radioactivity at Atomic Energy Commission Installations 235

1. Bettis Atomic Power Laboratory, January–June 1966 235
2. Feed Materials Production Center, January–June 1966 237
3. Knolls Atomic Power Laboratory, January–June 1966 239
4. S1C Prototype Reactor Facility, January–June 1966 241

SECTION V. TECHNICAL NOTES 244

Reported Nuclear Detonations, March 1967 244

Synopses iii

Errata iii

Symbols, Units, and Equivalents .... Inside back cover

RADIOLOGICAL HEALTH DATA AND REPORTS

Published under the direction of

James G. Terrill, Jr., Director and
Dr. Raymond T. Moore, Deputy Director
National Center for Radiological Health

by the Standards and Intelligence Branch
National Center for Radiological Health
Donald L. Snow, Chief

BOARD OF EDITORIAL ADVISORS

Dr. Hugh B. Mitchell
Department of Defense
Dr. Ronald G. Menzel
Department of Agriculture
Dr. Wilfrid B. Mann
Department of Commerce
Robert E. Simpson
Food & Drug Administration, DHEW
John A. Harris
Atomic Energy Commission

STAFF

Managing Editor
Samuel Wieder
Assistant Managing Editor
Charles F. Coyle
Senior Technical Editor
Marvin Rosenstein
Technical Editors
Kurt L. Feldmann
Richard Wromble
Illustrator
Marylee Hill

Address correspondence to the Managing Editor, *Radiological Health Data and Reports*, National Center for Radiological Health, Public Health Service, Rockville, Maryland 20852.

For subscriptions to *Radiological Health Data and Reports*, please use the order form on last page of this issue.

U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service ● National Center for Radiological Health

Reports

PLUTONIUM-239 IN TOTAL DIET AND MILK

P. E. Kauffman and *P. J. Magno*[1]

The National Center for Radiological Health initiated a program in July 1965 to determine the level of plutonium–239 in the total diet and milk. The diet samples were obtained from the Institutional Total Diet Sampling Network of the Public Health Service and the milk samples were obtained from the PHS Pasteurized Milk Network. Using a gastrointestinal absorption factor of 3×10^{-5} as suggested by the International Commission on Radiological Protection, the average amount of plutonium–239 reaching the blood stream from the diet is estimated to be 2×10^{-4} femtocuries per day.

Radionuclides of plutonium have been introduced into the environment during past atmospheric weapons testing, and also from the burnup of the SNAP–9A satellite which used plutonium as a power source (*1, 2*). As part of its program to assess radiation exposures from food intake, the National Center for Radiological Health initiated a program in July 1965 at the Northeastern Radiological Health Laboratory to determine the levels of plutonium–239 in the total diet and milk.

The diet samples analyzed as part of this program were obtained from the Institutional Total Diet Sampling Network (ITDSN) of the Public Health Service. The ITDSN was originally designed to estimate the dietary intake of radionuclides in a selected population group ranging from children to young adults (*3*). In July 1965, when the plutonium sampling program was initiated so the institutions sampled included only children from 9 to 12 years of age (*4*). The milk samples analyzed were obtained from the PHS Pasteurized Milk Network (PMN), whose stations are selected to provide nationwide surveillance of milk-production and consumption areas (*5*).

Sample collection

For the purposes of this study, the United States was divided into six regions: Northeast, South, Delta, Central, Southwest, and Northwest. Monthly samples from each of the ITDSN and PMN sampling stations were composited and analyzed according to these regions. Figure 1 shows the ITDSN and PMN sampling stations in each of the designated regions.

Analytical methodology (6)

The samples were dry-ashed at 525°C. Plutonium–236 was added as a tracer and the ash leached with nitric acid. Any insoluble residue was ignited in a muffle furnace at 600°C. and then fumed with hydrofluoric and perchloric acids. The remaining salts were dissolved in hydrochloric acid and this solution combined with nitric acid leach.[2] Plutonium was then reduced to the +3 oxidation state with hydroxylamine hydrochloride and coprecipitated with the alkaline earth phosphates by addition of ammonium hydroxide. The alkaline earth phosphate precipitate was dissolved in 7.2M nitric acid and the plutonium oxidized to the +4 state with sodium nitrite. The solution

---

[1] Mr. Kauffman is program coordinator, Analytical Quality Control Service; and Mr. Magno is chief, Heavy Elements Section; Northeastern Radiological Health Laboratory, Public Health Service, Winchester, Mass. 01890.

[2] In the analysis of the total diet samples, a very small residue remained after this treatment and was discarded.

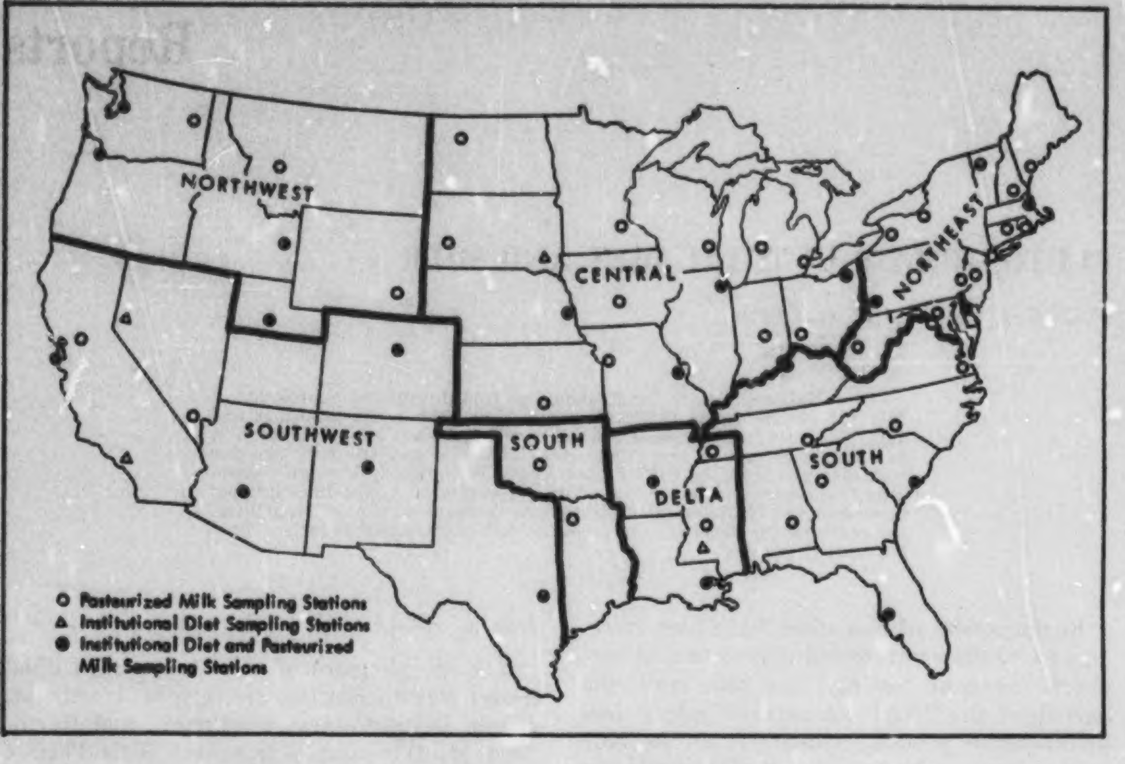

NORTHWEST
CENTRAL
NORTHEAST
SOUTHWEST
SOUTH
SOUTH
DELTA
○ Pasteurized Milk Sampling Stations
△ Institutional Diet Sampling Stations
● Institutional Diet and Pasteurized Milk Sampling Stations

Figure 1. Pasteurized milk and institutional diet sampling stations according to regions used for plutonium composites

was then passed over an anion exchange resin in the nitrate form. The resin was washed with additional 7.2M nitric acid and then with 9M hydrochloric acid. The plutonium was eluted from the resin with a mixture of 0.36M hydrochloric acid and 0.01M hydrofluoric acid, electroplated onto a stainless-steel planchet from a sulfuric acid—ammonium sulfate electrolyte, and counted in an alpha-particle spectrometer.

The energies of the alpha particles from plutonium–239 and plutonium–240 are not sufficiently different to be separated by alpha-particle spectrometry. Therefore, when plutonium–239 is referred to in this report, it represents the sum of the activities of plutonium–239 and plutonium–240.

The samples were usually counted for at least 1,000 minutes. Reagent blanks containing plutonium–236 tracer were run concurrently with the samples. The alpha-particle activity of plutonium–239 was converted to femtocuries (fCi or 10^{-15} curies) of the radionuclide per sample from the following equation:

$$^{239}\mathrm{Pu} = \frac{(A-B)C}{(D-E)}$$

^{239}Pu = fCi per sample of plutonium–239

where,

A = gross counts per minute (CPM) in plutonium–239 spectral region,

B = reagent blank counts per minute in plutonium–239 spectral region,

C = fCi plutonium–236 added,

D = gross counts per minute in plutonium–236 spectral region,

and,

E = background counts per minute in plutonium–236 spectral region.

A silicon surface barrier detector with an active area of 4.5 cm² was used. With the sample electroplated onto a 3.1 cm² area, the counting efficiency was 31 percent and the resolution 75 keV (full width half maximum).

Results

Tables 1 and 2 present the results of the analyses of plutonium–239 in the composite monthly samples of milk and of food collected in each region from July to December 1965. The analytical error for each determination (which at these levels consists of only the counting error) is given. The analytical errors presented in this article for the average for each region and the overall averages were calculated from the errors for the individual samples by standard propagation-of-error techniques, as indicated in the tables.

The data in table 1 show that the concentrations of plutonium–239 in milk in each of the six regions were generally less than their associated analytical error which ranged from approximately 1 to 6 fCi/kg.

The data in table 2 show that the concentrations of plutonium–239 in the total diet samples were often detectable above background, with the maximum value being 9.3 ± 4.2 fCi/kg. The average values from the six regions ranged from 2.7 ± 2.3 to 5.8 ± 1.7 fCi/kg; and the overall average value for the 34 samples analyzed was 3.8 ± 0.9 fCi/kg. It should be noted that all these values include the diluting effect of the milk component of the diet. The plutonium–239 concentrations of the non-milk portions of the diet would be somewhat higher than those indicated here.

Dietary intakes for plutonium–239 are presented in table 3 and were obtained by multiplying the ITDSN food consumption rate (7) in kg/day times the concentrations given in table 2. The maximum observed dietary intake was 18.1 ± 8.1 fCi/day. The average values for the six regions for July–December 1965 ranged from 5.0 ± 4.1 to 10.8 ± 3.2 fCi/day, with an overall average of 7.0 ± 1.6 fCi/day.

Table 1. Plutonium-239 in PMN composite milk samples, July–December 1965

Region	Plutonium-239 [a] concentrations ±E [b] (fCi/kg)					
	July	August	September	October	November	December
Northeast	1.0±1.4	(c)	3.5±3.5	(c)	(c)	1.9±1.6
South	0.2±1.1	0.0±1.1	3.1±4.2	(c)	0.2±1.1	0.0±0.9
Delta	0.0±5.0	(c)	2.8±4.7	(c)	(c)	(d)
Central	0.4±1.3	(c)	0.9±1.8	(c)	0.4±2.1	0.1±0.9
Southwest	0.4±2.4	0.0±6.2	(c)	(c)	2.2±2.1	0.4±1.2
Northwest	(c)	1.5±4.3	(c)	(c)	0.2±1.0	0.0±1.8

[a] Represents plutonium-239 and plutonium-240.
[b] E, analytical error (2σ counting error).
[c] Observed values were less than background.
[d] Sample lost.
[e] Sample not received.

Table 2. Plutonium-239 in ITDSN composite institutional diet samples, July–December 1965

Region	Plutonium-239 [a] concentrations ±E [b] (fCi/kg)						
	July	August	September	October	November	December	Average
Northeast	7.0±5.0	6.4±3.5	5.2±2.8	(c)	1.2±6.3	(c)	[d] 2.7±2.3
South	6.7±5.1	4.8±7.8	2.2±6.5	7.7±4.7	(c)	6.1±3.0	4.5±2.1
Delta	2.0±2.9	0.9±5.0	3.2±4.4	7.9±8.8	0.6±3.1	(d)	2.9±2.4
Central	3.2±3.1	1.2±3.5	8.5±5.5	(c)	1.0±5.5	9.3±4.2	3.6±2.0
Southwest	4.8±5.0	1.9±3.1	(e)	2.2±4.5	2.4±4.8	4.8±3.5	3.2±1.9
Northwest	7.3±5.4	4.2±2.5	5.4±3.3	3.4±5.5	5.5±3.3	8.8±4.2	5.8±1.7

[a] Represents plutonium-239 and plutonium-240.
[b] E, analytical error (2σ counting error).
[c] Observed values were less than background. The actual negative numbers obtained were used in computing the average to avoid a statistical bias. They are given below:

Northeast:	October	−1.4±5.2 fCi/kg
	December	−2.2±9.5
South:	November	−0.3±1.4
Central:	October	−1.8±6.9

[d] The analytical error of the average value was calculated using the formula:

$$E(avg) = \frac{\sqrt{\Sigma(E)^2}}{n}$$

[e] Sample lost.

Table 3. ITDSN dietary intake of plutonium-239, July–December 1965

Region	Plutonium-239[a] intake ±E[b] (fCi/day)						
	July	August	September	October	November	December	Average
Northeast	12.9±9.2	12.9±7.1	10.9±5.9	(c)	2.5±13.2	(c)	[d]5.3±4.8
South	10.7±8.1	9.1±14.9	[illegible].5±10.3	13.4±8.2	(c)	10.5±5.2	7.8±2.7
Delta	4.5±6.5	1.9±10.6	5.5±7.6	11.8±13.1	1.2±6.3	(e)	5.0±4.1
Central	6.0±5.8	2.4±7.0	14.6±9.5	(c)	1.9±10.0	18.1±8.1	6.6±3.7
Southwest	9.3±9.7	3.2±5.3	(e)	4.3±5.8	4.5±9.0	9.3±6.8	6.1±3.6
Northwest	14.1±10.4	8.5±5.1	10.0±6.2	6.3±10.1	10.0±6.0	15.8±7.6	10.8±3.2

[a] Represents plutonium-239 and plutonium-240.

[b] E, analytical error (2σ counting error).

[c] Values less than zero. The intakes representing these analyses result from the negative (less than background) concentrations observed. The actual negative intakes calculated were used in compositing averages to avoid statistical bias. They are given below:

Northeast:	October	−3.2±11.7
	December	−4.2±18.1
South:	November	−0.5±2.4
Central:	October	−3.3±12.6

[d] The analytical error of the average value was calculated using the formula:

$$E(avg) = \frac{\sqrt{\Sigma(E)^2}}{n}$$

[e] Sample lost.

The recommendation of the International Commission on Radiological Protection (*8*) for the maximum permissible concentration $(MPC)_w$ of plutonium-239 in water for the general population is one-tenth the $(MPC)_w$ for the 168-week occupational exposure. This yields a $(MPC)_w$ for the general population of 5×10^{-6} μCi/cc, which in turn results in a daily intake of 1.1×10^7 fCi/day, based on a water intake of 2.2 liters/day. Since the $(MPC)_w$'s for plutonium-239 and plutonium-240 are the same, it is not significant whether the activity observed was from only plutonium-239 or whether the activity observed included a plutonium-240 component. In comparison to this guideline, the levels of plutonium-239 observed in the total diets analyzed are seen to be extremely small—in fact, to approach the level of analytical detectability.

Using a gastrointestinal absorption factor for plutonium-239 of 3×10^{-5} as suggested by the International Commission on Radiological Protection (*8*), the calculated amount of plutonium-239 reaching the blood stream from the above diets is estimated to be 2×10^{-4} fCi/day.

REFERENCES

(*1*) LANGHAM, W., and E. C. ANDERSON. Entry of radioactive fallout into the biosphere and man. Bull Swiss Acad Med Sci 14:434–478 (1958).

(*2*) HARLEY, J. H. Possible ^{238}Pu distribution from a satellite failure, HASL-149:138–141 (1965).

(*3*) ANDERSON, E. C., and D. J. NELSON. Surveillance for radiological contamination in foods. Amer J Public Health 52:1391–1400 (September 1962).

(*4*) PUBLIC HEALTH SERVICE, DIVISION OF RADIOLOGICAL HEALTH. Radionuclides in institutional diet samples, October-December and annual summary 1965. Radiol Health Data Rep 7:398–403 (July 1966).

(*5*) PUBLIC HEALTH SERVICE. Pasteurized Milk Network, August 1965. Radiol Health Data 6:677–681 (December 1965).

(*6*) KAUFFMAN, P. E. Procedures for the determination of isotopic plutonium in environmental and biological samples. Northeastern Radiological Health Laboratory, Winchester, Mass. 01890 (mimeographed report).

(*7*) PUBLIC HEALTH SERVICE. Radionuclides in institutional diet samples, July-September 1965. Radiol Health Data Rep 7:288–292 (May 1966).

(*8*) INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION. Recommendations of the International Commission on Radiological Protection, Report No. 2. Pergamon Press, New York, N. Y. (1959).

Data

Section I. Milk and Food

In the determination of the internal exposure to man from environmental radiation sources, primary interest centers on radionuclides in the diet. Efforts are being made by both Federal and State agencies to monitor the intake of various radionuclides in the total diet on a continuing basis. The total diet is the most direct measure of intake of radionuclides; however, because specific dietary data are not readily available, indicator foods may be used to estimate radionuclide intake.

Fresh milk is consumed by a large segment of the U.S. population. It contains most of the biologically significant radionuclides from nuclear test debris which appear in the diet and is the major source of dietary intake of short-lived radionuclides. For these reasons, it is the single food item most often used as an indicator of the population's intake of radionuclides. In the absence of specific information, one may assume that the total daily dietary intake of selected radionuclides is equivalent to the intake represented by the consumption of 1 liter of milk. More direct estimates of dietary intake of radionuclides than those furnished by indicator foods can be obtained by analyses of the total diet or representative principal food items or groups combined with appropriate consumption data.

The Federal Radiation Council (FRC) has developed Radiation Protection Guides (RPG's) for controlling normal peacetime nuclear operations, assuming continuous exposure from intake by the population at large (*1–3*). The RPG's do not and cannot establish a line which is safe on one side and unsafe on the other; they do provide an indication of when there is a need to initiate careful evaluation of exposure (*3*). Additional guidelines are provided by the FRC Protective Action Guides (*4*) and by the International Commission on Radiological Protection (*5,6*).

Data from selected national, international, and State milk and food surveillance activities are presented herein. An effort has been made to present a cross-section of routine sampling programs which may be considered of a continuing nature. Routine milk sampling has been defined as one or more samples collected per month.

REFERENCES

(*1*) FEDERAL RADIATION COUNCIL. Background material for the development fo radiation protection standards, Report No. 1. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (May 13, 1960).

(*2*) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (September 1960).

(*3*) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, protective action for strontium–89, strontium–90, and cesium–137, Report No. 7. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (May 1965).

(*4*) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, Report No. 5. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (July 1964).

(*5*) INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION. Recommendation of the International Commission on Radiological Protection, Report No. 2. Pergamon Press, New York, N.Y. (1959).

(*6*) INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION. Recommendation of the International Commission on Radiological Protection, Report No. 6. Pergamon Press, New York, N.Y. (1965).

NATIONAL AND INTERNATIONAL MILK SURVEILLANCE

As part of continuing efforts to quantitatively monitor man's exposure to radionuclides, various national and international organizations routinely monitor radionuclide levels in milk. In addition to the programs reported below, *Radiological Health Data and Reports* coverage includes:

Program	Period reported	Last presented
Radiostrontium in milk, HASL	January-June 1966	March 1967

---

1. Pasteurized Milk Network
December 1966

National Center for Radiological Health and National Center for Urban and Industrial Health, PHS

The Public Health Service's Pasteurized Milk Network (PMN) was designed to provide nationwide surveillance of radionuclide concentrations in milk through sampling from major milk production and consumption areas. The present network of 63 sampling stations (figure 1) provides data on milk in every State, the Canal Zone, and Puerto Rico. The most recent description of the sampling and analytical procedures employed by the PMN appeared in the December 1966 issue of *Radiological Health Data and Reports* (1).

The results for December 1966 and fourth quarter of 1966 are presented in table 1. The average monthly radionuclide concentrations

Stations Not Shown
Palmer, Alaska
Honolulu, Hawaii
San Juan, Puerto Rico
Cristobal, Canal Zone
● Sampling Station

Figure 1. Pasteurized Milk Network sampling stations

Table 1. Average concentrations of radionuclides in pasteurized milk for the fourth quarter and December 1966

Sampling location		Strontium-89 (pCi/liter)		Strontium-90 (pCi/liter)		Iodine-131 (pCi/liter)		Cesium-137 (pCi/liter)		Barium-140 (pCi/liter)	
		Fourth quarter 1966	Dec 1966	Fourth quarter 1966	Dec 1966	Fourth quarter 1966	Dec 1966	Fourth quarter 1966	Dec 1966	Fourth quarter 1966	Dec 1966
Ala:	Montgomery	<5	<5	10	9	0	0	15	15	0	0
Alaska:	Palmer	<5	<5	14	13	0	0	25	25	0	0
Ariz:	Phoenix	<5	<5	3	2	0	0	5	<5	0	0
Ark:	Little Rock	5	5	24	23	0	0	20	20	0	0
Calif:	Sacramento	<5	<5	3	3	0	0	5	5	0	0
	San Francisco	<5	<5	3	2	0	0	10	5	0	0
C.Z.:	Cristobal	<5	<5	5	4	0	0	25	25	0	0
Colo:	Denver	<5	<5	8	5	0	0	10	10	0	0
Conn:	Hartford	<5	<5	10	10	0	0	20	25	0	0
Del:	Wilmington	<5	<5	12	13	0	0	20	25	0	0
D.C:	Washington	<5	<5	12	12	0	0	15	15	0	0
Fla:	Tampa	10	10	10	8	0	0	95	80	0	0
Ga:	Atlanta	5	5	16	15	0	0	25	25	0	0
Hawaii:	Honolulu	<5	<5	4	4	0	0	15	15	0	0
Idaho:	Idaho Falls	<5	<5	9	8	0	0	15	15	0	0
Ill:	Chicago	<5	<5	8	5	0	0	15	20	0	0
Ind:	Indianapolis	<5	<5	10	10	0	0	15	20	0	0
Iowa:	Des Moines	<5	<5	9	8	0	0	15	15	0	0
Kans:	Wichita	<5	<5	14	18	0	0	10	10	0	0
Ky:	Louisville	10	10	13	13	0	0	10	10	0	0
La:	New Orleans	<5	<5	27	25	0	0	35	50	0	0
Maine:	Portland	<5	<5	14	13	0	0	45	45	0	0
Md:	Baltimore	<5	<5	11	10	0	0	15	15	0	0
Mass:	Boston	<5	<5	13	13	0	0	35	35	0	0
Mich:	Detroit	<5	<5	10	12	0	0	15	20	0	0
	Grand Rapids	<5	<5	12	13	0	0	20	20	0	0
Minn:	Minneapolis	<5	<5	21	24	0	0	15	15	0	0
Miss:	Jackson	15	15	17	15	0	0	15	15	0	0
Mo:	Kansas City	<5	<5	11	9	0	0	10	10	0	0
	St. Louis	<5	<5	12	10	0	0	15	15	0	0
Mont:	Helena	<5	<5	12	14	0	0	20	15	0	0
Nebr:	Omaha	<5	<5	10	8	0	0	10	10	0	0
Nev:	Las Vegas	<5	<5	3	3	0	0	10	10	0	0
N.H:	Manchester	<5	<5	15	17	0	0	45	45	0	0
N.J:	Trenton	<5	<5	10	11	0	0	20	20	0	0
N. Mex:	Albuquerque	<5	<5	4	5	0	0	5	5	0	0
N.Y:	Buffalo	<5	<5	9	9	0	0	20	20	0	0
	New York	<5	<5	12	12	0	0	25	25	0	0
	Syracuse	<5	<5	9	9	0	0	20	30	0	0
N.C:	Charlotte	<5	<5	20	19	0	0	20	20	0	0
N. Dak:	Minot	<5	<5	24	21	0	0	20	20	0	0
Ohio	Cincinnati	<5	<5	10	9	0	0	15	15	0	0
	Cleveland	<5	<5	10	11	0	0	20	25	0	0
Okla:	Oklahoma City	<5	<5	9	8	0	0	10	10	0	0
Ore:	Portland	<5	<5	10	8	0	0	20	20	0	0
Penn:	Philadelphia	<5	<5	11	11	0	0	20	20	0	0
	Pittsburgh	<5	<5	14	15	0	0	20	25	0	0
P.R.:	San Juan	5	5	6	5	0	0	15	15	0	0
R.I:	Providence	<5	<5	12	11	0	0	25	25	0	0
S.C:	Charleston	<5	<5	20	19	0	0	30	30	0	0
S. Dak:	Rapid City	<5	<5	16	13	0	0	15	20	0	0
Tenn:	Chattanooga	<5	<5	18	18	0	0	20	20	0	0
	Memphis	<5	<5	14	12	0	0	10	10	0	0
Tex:	Austin	<5	<5	4	4	0	0	5	5	0	0
	Dallas	<5	<5	10	10	0	0	10	15	0	0
Utah:	Salt Lake City	<5	<5	12	16	0	0	15	15	0	0
Vt:	Burlington	<5	<5	11	11	0	0	25	25	0	0
Va:	Norfolk	10	10	14	13	0	0	15	10	0	0
Wash:	Seattle	<5	<5	16	12	0	0	35	25	0	0
	Spokane	<5	<5	14	13	0	0	25	25	0	0
W. Va:	Charleston	5	5	15	13	0	0	10	10	0	0
Wis:	Milwaukee	<5	<5	9	9	0	0	15	15	0	0
Wyo:	Laramie	<5	<5	8	10	0	0	10	10	0	0
Network average		<5	<5	11.7	11.3	0	0	20	20	0	0

Table 2. Frequency distribution, strontium-90 concentrations in milk at Pasteurized Milk Network stations, December 1965 and July–December 1966

Strontium-90 (pCi/liter)	Number of stations						
	1965	1966					
	Dec	July	Aug	Sept	Oct	Nov	Dec
Under 10	9	14	15	21	18	19	23
10–19	43	39	40	37	39	40	35
20–29	11	9	7	5	6	4	5
30–39	0	1	1	0	0	0	0

Table 3. Frequency distribution, cesium-137 concentrations in milk at Pasteurized Milk Network stations, December 1965 and July–December 1966

Cesium-137 (pCi/liter)	Number of stations						
	1965	1966					
	Dec	July	Aug	Sept	Oct	Nov	Dec
Under 50	51	56	56	61	62	61	62
50–99	11	6	6	1	0	2	1
100–149	1	1	1	1	1	0	0
150–199	0	0	0	0	0	0	0

Table 4. Iodine-131 concentrations, pCi/liter, in Pasteurized

Station location		December 1966														
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Ala:	Montgomery	<10							<10						<10	
Alaska:	Palmer						<10							<10		
Ariz:	Phoenix	<10							<10							<10
Ark:	Little Rock					<10							<10			
Calif:	Sacramento		<10							<10						
	San Francisco	<10							<10							<10
C.Z.	Cristobal					<10							<10			
Colo:	Denver									<10						<10
Conn:	Hartford		<10							<10						
Del:	Wilmington	<10							16							<10
D.C.	Washington	<10							<10							<10
Fla:	Tampa							<10								<10
Ga:	Atlanta							<10					<10			
Hawaii:	Honolulu						<10							<10		
Idaho:	Idaho Falls					<10							<10			
Ill:	Chicago						<10							<10		
Ind:	Indianapolis					<10							<10			
Iowa:	Des Moines	<10							<10							<10
Kans:	Wichita					<10							<10			
Ky:	Louisville						<10							<10		
La:	New Orleans	<10							<10						<10	
Maine	Portland					<10							<10			
Md:	Baltimore						<10							<10		
Mass:	Boston						<10							<10		
Mich:	Detroit						<10							<10		
	Grand Rapids					<10							<10			
Minn:	Minneapolis						<10							<10		
Miss:	Jackson					<10							<10			
Mo:	Kansas City		<10							10						
	St. Louis		<10							<10						
Mont:	Helena						<10								<10	
Nebr:	Omaha	<10								<10						<10
Nev:	Las Vegas							<10								
N.H:	Manchester						<10							<10		
N.J:	Trenton						<10							<10		
N. Mex:	Albuquerque					<10							<10			
N.Y:	Buffalo		<10							<10						
	New York					<10							<10			
	Syracuse								12						<10	
N.C:	Charlotte					<10							<10			
N. Dak:	Minot					<10							<10			
Ohio:	Cincinnati					<10								<10		
	Cleveland									<10						
Okla:	Oklahoma City		12							<10						
Ore:	Portland		<10							<10						
Pa:	Philadelphia		14							<10						
	Pittsburgh						<10							<10		
P.R:	San Juan					<10							<10			
R.I:	Providence						<10							<10		
S.C:	Charleston						<10							<10		
S. Dak:	Rapid City					<10							<10			
Tenn:	Chattanooga	<10							<10							<10
	Memphis	<10							<10							<10
Tex:	Austin		18							<10						
	Dallas					<10							<10			
Utah:	Salt Lake City					<10							<10			<10
Vt:	Burlington							<10							<10	
Va:	Norfolk		<10							<10						
Wash:	Seattle	<10							<10							<10
	Spokane						<10							<10		
W. Va:	Charleston			12							<10					
Wis:	Milwaukee	<10								<10						
Wyo:	Laramie							<10							<10	

are based on results obtained from samples collected weekly. If radionuclide values were below minimum detectable concentrations (*1*), averages were calculated using one-half the minimum detectable value; however, for iodine-131 and barium-140, zero was used for averaging purposes when concentrations were below minimum detectable levels.

For comparative purposes, distributions of strontium-90 and cesium-137 are presented in

Milk Network samples, December 1966

December 1966—Continued																Station location	
16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31		
------	------	------	------	<10	------	------	------	------	------	------	------	<10	------	------	------	Ala:	Montgomery.
------	------	------	------	<10	------	------	------	------	<10	------	------	------	------	------	------	Alaska:	Palmer.
------	------	------	------	------	------	------	<10	------	------	------	------	------	<10	------	------	Ariz:	Phoenix.
------	------	------	<10	------	------	------	------	------	------	------	------	------	------	------	------	Ark:	Little Rock.
<10	------	------	------	------	------	------	<10	------	------	------	------	------	------	<10	------	Calif:	Sacramento.
------	------	------	------	------	------	<10	------	------	------	------	------	------	<10	------	------		San Francisco.
------	------	------	<10	------	------	------	------	------	------	------	<10	------	------	------	------	C.Z:	Cristobal.
------	------	------	------	------	11	------	------	------	------	------	------	------	<10	------	------	Colo:	Denver.
<10	------	------	------	------	------	------	<10	------	------	------	------	------	------	<10	------	Conn:	Hartford.
------	------	------	------	------	------	<10	------	------	------	------	------	<10	------	------	------	Del:	Wilmington.
------	------	------	------	------	------	<10	------	------	------	------	------	------	------	<10	------	D.C:	Washington.
------	------	------	<10	------	------	------	------	------	------	------	<10	------	------	------	------	Fla:	Tampa.
------	------	------	------	------	<10	------	------	------	------	------	<10	------	------	------	------	Ga:	Atlanta.
------	------	------	------	<10	------	------	------	------	------	------	<10	------	------	------	------	Hawaii:	Honolulu.
------	------	------	<10	------	------	------	------	------	------	------	<10	------	------	------	------	Idaho:	Idaho Falls.
------	------	------	------	14	------	------	------	------	------	------	<10	------	------	------	------	Ill:	Chicago.
------	------	------	<10	------	------	------	------	------	------	------	<10	------	------	------	------	Ind:	Indianapolis.
------	------	------	------	------	------	<10	------	------	------	------	------	------	<10	------	------	Iowa:	Des Moines.
------	------	------	<10	------	------	------	------	------	------	<10	------	------	------	------	------	Kans:	Wichita.
------	------	------	------	<10	------	------	------	------	------	------	<10	------	------	------	------	Ky:	Louisville.
------	------	------	------	------	<10	------	------	------	------	------	------	------	<10	------	------	La:	New Orleans.
------	------	------	<10	------	------	------	------	------	------	------	11	------	------	------	------	Maine:	Portland.
------	------	------	------	11	------	------	------	------	------	------	<10	------	------	------	------	Md:	Baltimore.
------	------	------	------	10	------	------	------	------	------	------	<10	------	------	------	------	Mass:	Boston.
------	------	------	------	<10	------	------	------	------	------	------	23	------	------	------	------	Mich:	Detroit.
------	------	------	<10	------	------	------	------	------	------	------	<10	------	------	------	------		Grand Rapids.
------	------	------	------	<10	------	------	------	------	------	------	<10	------	------	------	------	Minn:	Minneapolis.
------	------	------	<10	------	------	------	------	------	------	------	------	------	------	------	------	Miss:	Jackson.
<10	------	------	------	------	------	------	<10	------	------	------	------	------	------	<10	------	Mo:	Kansas City.
<10	------	------	------	------	------	------	<10	------	------	------	------	------	------	<10	------		St. Louis.
------	------	------	------	<10	------	------	------	------	------	------	<10	------	------	------	------	Mont:	Helena.
------	------	------	------	------	------	------	<10	------	------	------	------	------	------	<10	------	Nebr:	Omaha.
<10	------	------	------	<10	------	------	------	------	------	------	------	<10	------	------	------	Nev:	Las Vegas.
------	------	------	------	<10	------	------	------	------	------	------	<10	------	------	------	------	N.H:	Manchester.
------	------	------	------	<10	------	------	------	------	------	------	<10	------	------	------	------	N.J:	Trenton.
------	------	------	<10	------	------	------	------	------	------	------	<10	------	------	------	------	N. Mex:	Albuquerque.
13	------	------	------	------	------	------	<10	------	------	------	------	------	------	<10	------	N.Y:	Buffalo.
------	------	------	10	------	------	------	------	------	------	------	<10	------	------	------	------		New York.
------	------	------	------	14	------	------	------	------	------	------	------	------	------	------	------		Syracuse.
------	------	------	<10	------	------	------	------	------	------	------	<10	------	------	------	------	N.C:	Charlotte.
------	------	------	<10	------	------	------	------	------	------	------	<10	------	------	------	------	N. Dak:	Minot.
------	------	------	------	------	14	------	------	------	------	------	------	<10	------	------	------	Ohio:	Cincinnati.
<10	------	------	------	------	------	13	------	------	------	------	------	------	------	10	------		Cleveland.
<10	------	------	------	<10	------	------	------	------	------	------	------	------	<10	------	------	Okla:	Oklahoma City.
<10	------	------	------	------	------	------	<10	------	------	------	------	------	------	<10	------	Ore:	Portland
<10	------	------	------	------	------	------	<10	------	------	------	------	------	------	<10	------	Pa:	Philadelphia.
------	------	------	------	<10	------	------	------	------	------	------	<10	------	------	------	------		Pittsburgh.
------	------	------	<10	------	------	------	------	------	------	------	------	------	------	------	------	P.R:	San Juan.
------	------	------	------	<10	------	------	------	------	------	------	<10	------	------	------	------	R.I:	Providence.
------	------	------	------	<10	------	------	------	------	------	------	------	------	------	------	------	S.C:	Charleston.
------	------	------	<10	------	------	------	------	------	------	------	<10	------	------	------	------	S. Dak:	Rapid City.
------	------	------	------	------	------	<10	------	------	------	------	------	------	<10	------	------	Tenn:	Chattanooga.
------	------	------	------	<10	------	------	------	------	------	------	------	<10	------	------	------		Memphis.
<10	------	------	------	------	------	<10	------	------	------	------	------	------	------	------	------	Tex:	Austin.
------	------	------	<10	------	------	------	------	------	------	------	------	------	------	------	------		Dallas.
------	------	------	------	<10	------	------	------	------	------	<10	------	------	------	------	------	Utah:	Salt Lake City.
------	------	------	------	------	<10	------	------	------	------	------	------	------	------	------	------	Vt:	Burlington.
<10	------	------	------	------	------	------	<10	------	------	------	------	------	------	<10	------	Va:	Norfolk.
------	------	------	------	------	------	<10	------	------	------	------	------	------	<10	------	------	Wash:	Seattle.
------	------	------	------	<10	------	------	------	------	------	------	<10	------	------	------	------		Spokane.
------	<10	------	------	------	------	------	------	------	------	------	------	------	------	------	<10	W. Va:	Charleston.
<10	------	------	------	------	<10	------	------	------	------	------	------	14	------	------	------	Wis:	Milwaukee.
------	------	------	------	------	<10	------	------	------	------	------	------	<10	------	------	------	Wyo:	Laramie.

tables 2 and 3 for December 1965 and July through December 1966. The average strontium-90 concentrations in pasteurized milk from selected cities are presented in figure 2. Individual iodine-131 milk concentrations for December 1966 are shown in table 4. Concentrations greater than the minimum detectable level of 10 pCi/liter are presumed to reflect the fourth Chinese atmospheric nuclear test of October 27, 1966, EST.

-12-

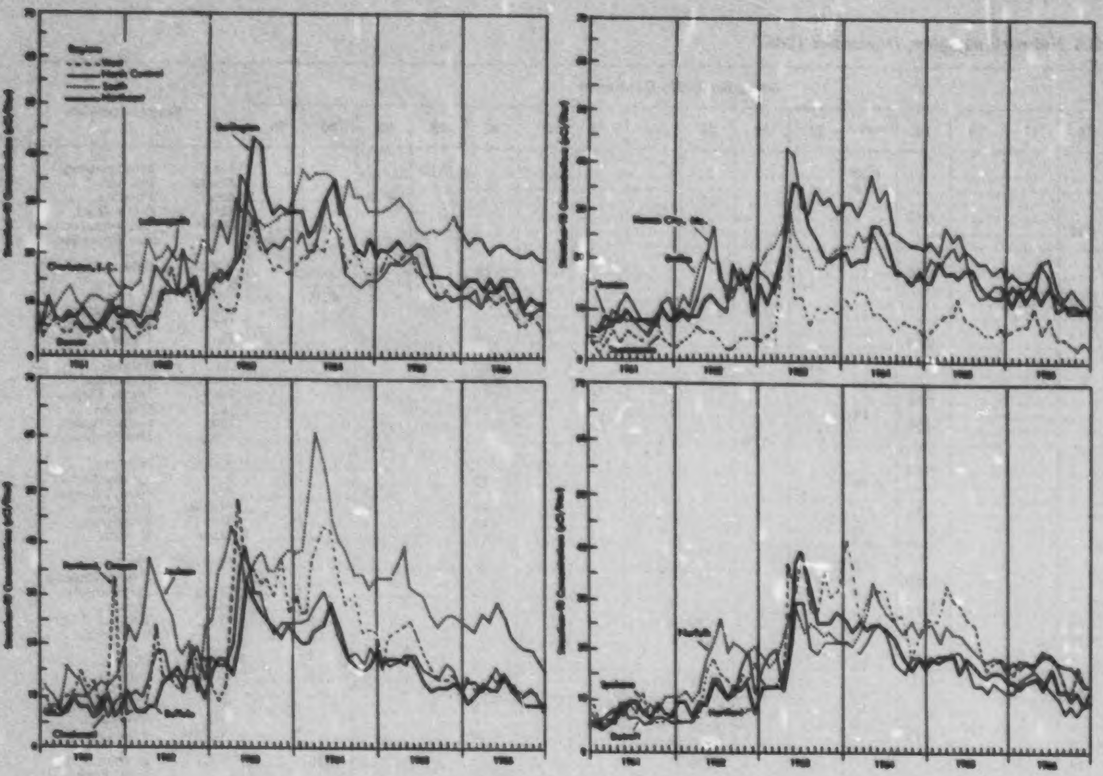


Figure 2. Strontium-90 concentrations in pasteurized milk, 1961–December 1966

2. Canadian Milk Network December 1966[1]

Radiation Protection Division
Department of National Health and Welfare

Since November 1955, the Radiation Protection Division of the Department of National Health and Welfare has been monitoring milk for radionuclide concentrations. Powdered milk was originally sampled, but liquid whole milk has been sampled since January 1963. At present, 16 milk sampling stations (figure 3) are in operation. Their locations coincide with air and precipitation sampling stations.

Milk samples are collected three times a

Table 5. Stable elements and radionuclides in Canadian wholemilk, December 1966

Station	Calcium (g/liter)	Potassium (g/liter)	Strontium-90 (pCi/liter)	Cesium-137 (pCi/liter)
Calgary	1.18	1.5	15.5	39
Edmonton	1.11	1.6	12.5	34
Ft. William	1.09	1.6	17.0	37
Fredericton	1.11	1.6	19.0	42
Halifax	1.10	1.5	16.1	41
Montreal	1.10	1.5	12.3	26
Ottawa	1.16	1.6	9.7	22
Quebec	1.11	1.6	16.8	48
Regina	1.14	1.6	13.4	36
St. John's, Nfld	1.13	1.6	19.2	48
Saskatoon	1.16	1.6	14.5	37
Sault Ste. Marie	1.13	1.6	13.0	37
Toronto	1.14	1.6	7.1	18
Vancouver	1.20	1.5	20.2	78
Windsor	1.15	1.6	6.8	17
Winnipeg	1.12	1.6	10.4	26
Average	1.13	1.6	14.1	35

---

[1] Prepared from January 1967 monthly reports "Data from Radiation Protection Programs," Canadian Department of National Health and Welfare, Ottawa, Canada.

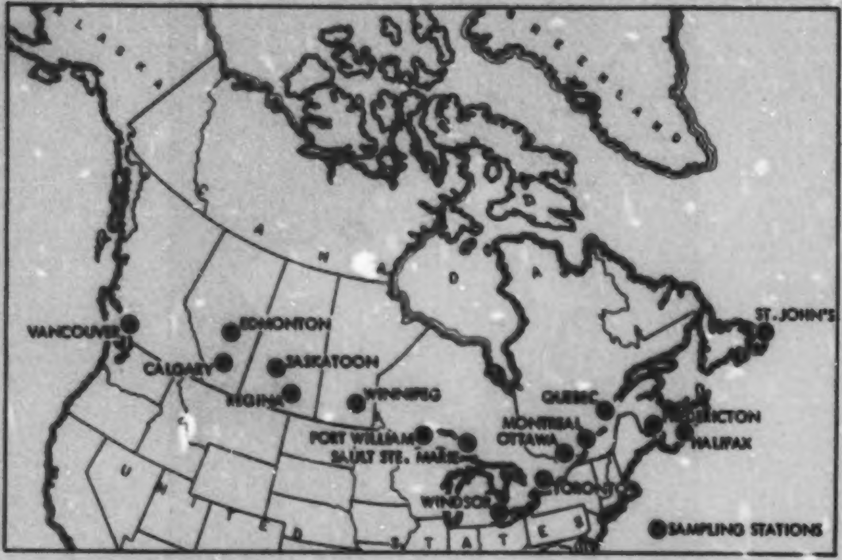

ALASKA
GREENLAND
CANADA
VANCOUVER
EDMONTON
CALGARY
SASKATOON
REGINA
WINNIPEG
FORT WILLIAM
SAULT STE. MARIE
WINDSOR
TORONTO
OTTAWA
MONTREAL
QUEBEC
FREDERICTON
HALIFAX
ST. JOHN'S
UNITED STATES
● SAMPLING STATIONS

Figure 3. Canadian milk sampling stations

week from selected dairies and are combined into weekly composites. The contribution of each dairy to the composite sample is directly proportional to the liquid volume of sales. Weekly spot check analyses are made for iodine-131, and monthly composites are analyzed for strontium-90, cesium-137, and stable calcium and potassium. The analytical procedures were outlined in the December 1966 issue of *Radiological Health Data and Reports* (2).

The December 1966 monthly average strontium-90, cesium-137, and stable calcium and potassium concentrations in Canadian whole milk are presented in table 5. Iodine-131 and strontium-89 concentrations were below minimum detectable levels.

3. Pan American Milk Sampling Program December 1966

Pan American Health Organization and U.S. Public Health Service

The Pan American Health Organization (PAHO), in collaboration with the U.S. Public Health Service (PHS), furnishes assistance to health agencies in the American republics in developing national radiological health programs.

Under a joint agreement between the agencies, air and milk sampling activities are conducted by a number of PAHO member countries (figure 4). Results of the milk sampling program are presented below. Further information on the sampling and analytical procedures employed was presented in the December 1966 issue of *Radiological Health Data and Reports* (3).

Table 6 presents stable potassium, strontium-89, strontium-90, and cesium-137 monthly average concentrations for December 1966.

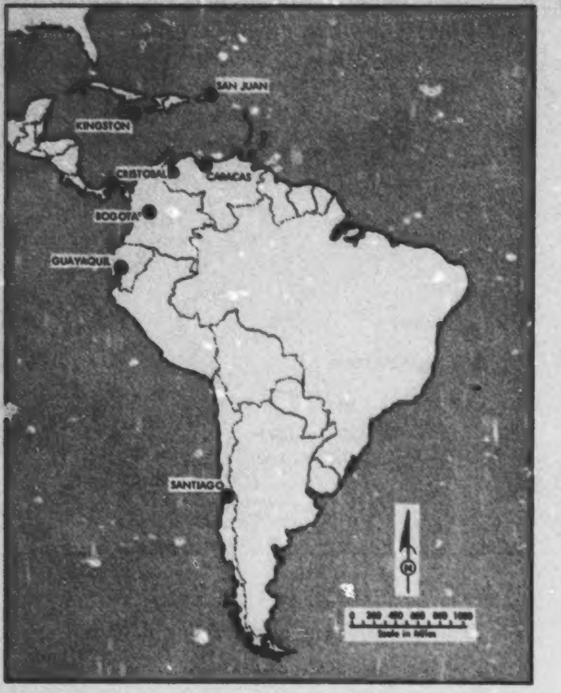


Figure 4. Pan American Milk Sampling Program locations

Table 6. Stable element and radionuclide concentrations in PAHO milk, December 1966 [a]

Sampling stations		Number of Samples	Potassium (g/liter)	Strontium-89 [b] (pCi/liter)	Strontium-90 (pCi/liter)	Cesium-137 (pCi/liter)
Chile:	Santiago	4	1.52	5	2	7
Colombia:	Bogota	1	1.49	5	4	10
Ecuador:	Guayaquil	NS				
Jamaica:	Kingston	NS				
	Mandeville	NS				
	Montego Bay	1	1.43	10	10	320
Venezuela:	Caracas	NS				
Canal Zone:	Cristobal [c]	4	NA	<5	4	25
Puerto Rico:	San Juan [c]	4	NA	5	5	15

[a] Iodine-131 and barium-140 were below the detectable limits of 10 pCi/liter.

[b] Data have been corrected for decay to the date of sample collection.

[c] For comparison purposes, the radionuclide concentrations at Cristobal, Canal Zone; and San Juan, Puerto Rico, are presented.

NS, no sample collected.

NA, no analysis performed.

REFERENCES

(1) PUBLIC HEALTH SERVICE. Pasteurized Milk Network, August 1966. Radiol Health Data Rep 7:698–701 (December 1966).

(2) DEPARTMENT OF NATIONAL HEALTH AND WELFARE, RADIATION PROTECTION DIVISION. Canadian Milk Network, August 1966. Radiol Health Data Rep 7:702–703 (December 1966).

(3) PAN AMERICAN HEALTH ORGANIZATION and U.S. PUBLIC HEALTH SERVICE. Pan American Milk Sampling Program, August 1966. Radiol Health Data Rep 7:704–705 (December 1966).

STATE MILK SURVEILLANCE ACTIVITIES

Considerable progress has been made by the State health departments in initiating or expanding environmental surveillance activities in radiological health. Many of the States have developed comprehensive environmental surveillance programs.

The continuing efforts of State health departments in the analysis and monitoring of radionuclides in milk complement Federal milk surveillance activities. The results presented herein are representative of current surveillance activities directed at the use of milk as an indicator of dietary intake of radioactivity.

In addition to the State milk networks presented herein, programs previously covered in *Radiological Health Data and Reports* include:

State milk network	Period reported	Last presented
California	July-September 1966	March 1967
Colorado	May 1965-June 1966	October 1966
Connecticut	July-September 1966	February 1967
Florida	April-June 1966	October 1966
Indiana	July-September 1966	February 1967
Michigan	July-September 1966	February 1967
Minnesota	July-September 1966	February 1967
Oregon	July-September 1966	March 1967
New York	January-June 1966	February 1967
Pennsylvania	July-September 1966	February 1967
Washington	July-September 1966	March 1967

---

1. Oklahoma Milk Network
October-December 1966

Oklahoma State Department of Health[1]

In March 1965, the Radiological Health Section of the Oklahoma State Department of Health initiated a program of analysis for iodine-131 in the milk produced in the State of Oklahoma. In March 1966, analysis for cesium-137 was added to the program.

The location of the sampling stations and the extent of their associated milksheds are shown in figure 1. Of the 10 milksheds in the State of Oklahoma, 5 were chosen as sampling stations (Oklahoma City, Enid, Tulsa, Lawton, and Ardmore) on the basis of their size and location. A major criterion in the selection of a milkshed for sampling was the degree of overlap with other milksheds being sampled. This overlap assists in locating small areas of production where the iodine-131 concentrations might be abnormally high.

The sampling stations are located in the laboratory of a major milk processing plant in each milkshed. While the milkshed for a particular processing plant may not coincide exactly with that shown in figure 1, the coincidence is satisfactory for surveillance purposes.

At the present time, samples are collected on Monday morning, and the analyses are completed by Wednesday afternoon. However, if iodine-131 levels detected are such that diversion of the milk or other precautionary methods need to be taken, the analytical method and equipment can be employed to sample each truck arriving at the processing plan. Under these conditions, about 4 hours would be needed to complete the analysis. This reduced lag time

---

[1] Acknowledgement is accorded to the staff of the Radiological Health Section under the direction of Mr. Dale McHard, head, and Mr. Robert Craig, assistant engineer.

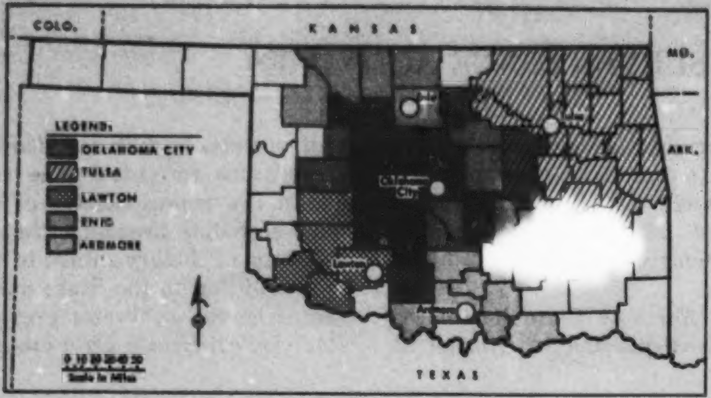


Figure 1. Oklahoma milkshed sampling areas

for analysis would permit rapid decisions on the fate of each truckload of raw milk.

Analytical method

The method of analysis is similar to that published by the U.S. Public Health Service (*1*) but was developed independently by the Oklahoma State Health Department's Radiological Health Laboratory.

The sampling stations are supplied with plastic cartridges containing 10 ml of Dowex 1X8 (50- to 100-mesh anion exchange resin). On the sampling date, 1 gallon of pasteurized whole milk is passed through the cartridge, the residual milk is washed from the resin with distilled water, and the cartridge is mailed to the Radiological Health Laboratory. The sample is analyzed for 100 minutes in a 2- by 2-inch well type, thallium-activated sodium iodide crystal, in conjunction with a 400-channel analyzer. The results are corrected to noon of the sampling date. The minimum detectable iodine-131 concentration in milk is 0.9 pCi/liter (3 standard deviations of background).

Results and discussion

Table 1 gives the concentrations of iodine-131 found in Oklahoma milk samples collected from October through December 1966. Cesium-137 concentrations are presented in table 2.

Recent coverage in *Radiological Health Data and Reports*:

Period	Issue
January–March 1966	July 1966
April–June 1966	October 1966
July–September 1966	January 1967

Table 1. Concentration of iodine-131 in Oklahoma milk, October–December 1966

Sampling date		Sampling location (concentration, pCi/liter)				
		Oklahoma City	Enid	Tulsa	Lawton	Ardmore
October	3	NS	NS	NS	NS	0
	10	0	0	0	NS	NS
	17	NS	NS	NS	0	0
	24	0	0	0	NS	NS
	31	NS	NS	NS	0	0
November	7	8	12	0	NS	NS
	14	19	5	38	NS	11
	21	0	0	0	NS	NS
	28	NS	NS	NS	0	0
December	5	0	NS	0	0	NS
	12	NS	7	NS	0	NS
	19	0	NS	0	NS	0
	26	IF	IF	IF	IF	IF

NS, no sample collected.
IF, instrument failure.

Table 2. Concentration of cesium-137 in Oklahoma milk, October–December 1966

Sampling date		Sampling location (concentration, pCi/liter)				
		Oklahoma City	Enid	Tulsa	Lawton	Ardmore
October	3	NS	NS	NS	NS	4
	10	10	NS	14	NS	NS
	17	NS	NS	NS	11	8
	24	13	13	7	NS	NS
	31	NS	NS	NS	22	8
November	7	21	38	18	NS	NS
	14	26	23	31	NS	27
	21	13	6	19	NS	NS
	28	NS	NS	NS	IF	0
December	5	4	NS	9	21	NS
	12	NS	46	NS	1	NS
	19	14	NS	24	NS	19
	26	IF	IF	IF	IF	IF

NS, no sample collected.
IF, instrument failure.

-17-

2. Tennessee Milk Network
July 1965-June 1966

Division of Preventable Diseases
Department of Public Health
State of Tennessee

The Tennessee Department of Public Health began sampling pasteurized milk for radionuclide analysis in July of 1965. Currently the Department is collecting milk samples every two weeks from three cities (figure 2). In order to obtain a representative sample of the milk consumed in the areas monitored, milk is collected from each distributor supplying the city. The samples from the individual distributors are then composited in proportion to the contribution each makes to the total city milk supply.

Analytical procedures

The biweekly milk samples from each of the three cities are analyzed by gamma-ray scintillation spectrometry for potassium-40, iodine-131, cesium-137, and barium-140, using a 3.5 liter sample (*2*). After gamma-ray analysis, the samples are stored for 2 weeks to allow ingrowth of daughter activity, after which stron-

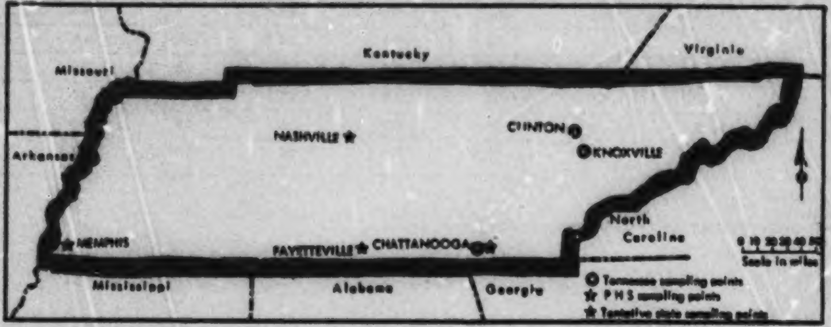

Missouri
Kentucky
Virginia
Arkansas
NASHVILLE
CLINTON
KNOXVILLE
MEMPHIS
FAYETTEVILLE
CHATTANOOGA
North Carolina
Mississippi
Alabama
Georgia
0 10 20 30 40 50
Scale in miles
Tennessee sampling points
P H S sampling points
Tentative state sampling points

Figure 2. Tennessee pasteurized milk network sampling stations

Table 3. Radionuclides in Chattanooga, Tennessee, pasteurized milk, July 1965–June 1966

Date	Concentration (pCi/liter)			Radionuclide concentration (pCi/liter)					
	Calcium	Potassium		Strontium-89	Strontium-90	Iodine-131	Cesium-137	Barium-140	
		A[a]	B[b]					A[a]	B[b]
1965									
July	1.18	1.71	NA	6	33	NA	56	[c]<5	8
August	1.20	1.75	NA	<5	27	NA	53	<5	<5
September	1.18	1.72	NA	<5	31	NA	47	<5	<5
October	1.20	1.67	NA	<5	25	NA	41	<5	6
November	1.21	1.51	NA	10	22	NA	48	<5	<5
December	1.12	1.57	1.73	<5	24	NA	42	<5	6
1966									
January	1.12	1.57	1.55	<5	24	<8	35	<5	8
February	1.15	1.52	1.49	<5	25	<8	39	<5	<5
March	1.21	1.47	1.52	<5	24	<8	43	<5	6
April	1.20	1.52	1.47	5	26	<8	41	<5	<6
May	1.23	1.47	1.51	6	23	<8	40	<5	5
June	1.20	1.56	1.51	30	23	14	39	<5	6

[a] A, gamma-ray analysis.
[b] B, chemical analysis.
[c] "Less than" sign (<) indicates values were below detectable limits.
NA, no analysis.

-18-

Table 4. Radionuclides in Clinton, Tennessee, pasteurized milk, July 1965–June 1966

Date	Concentration (pCi/liter)			Radionuclide concentration (pCi/liter)					
	Calcium	Potassium		Strontium-89	Strontium-90	Iodine-131	Cesium-137	Barium-140	
		A[a]	B[b]					A[a]	B[b]
1965									
July	1.19	1.75	NA	6	32	14	62	[c] <5	8
August	1.18	1.70	NA	<5	30	<8	40	<5	<5
September	1.18	1.65	NA	<5	31	9	49	<5	<5
October	1.21	1.70	NA	<5	26	14	47	<5	9
November	1.19	1.70	NA	6	25	18	45	<5	<5
December	1.12	1.70	1.75	<5	35	20	52	<5	<5
1966									
January	1.12	1.51	1.67	<5	22	4	43	<5	9
February	1.16	NA	1.52	<5	32	NA	NA	NA	<5
March	1.21	1.61	1.55	<5	33	<8	56	<5	<5
April	1.20	1.51	1.48	7	23	<8	47	<5	<5
May	1.23	1.52	1.54	<5	28	<8	44	<5	<5
June	1.17	1.54	1.51	46	24	13	42	<5	8

[a] A, gamma-ray analysis.
[b] B, chemical analysis.
[c] "Less than" sign (<) indicates values were below detectable limits.
NA, no analysis.

Table 5. Radionuclides in Knoxville, Tennessee, pasteurized milk, July 1965–June 1966

Date	Concentrtion (pCi/liter)			Radionuclide concentration (pCi/liter)					
	Calcium	Potassium		Strontium-89	Strontium-90	Iodine-131	Cesium-137	Barium-140	
		A[a]	B[b]					A[a]	B[b]
1965									
July	1.16	1.69	NA	11	24	19	57	[c] <5	<5
August	1.15	1.70	NA	<5	23	<8	42	<5	<5
September	1.15	1.74	NA	<5	21	9	39	<5	<5
October	1.19	1.71	NA	<5	20	11	43	5	<5
November	1.18	1.76	NA	<5	17	22	42	7	<5
December	1.13	1.61	1.77	<5	18	13	41	<5	<5
1966									
January	1.10	1.50	1.62	<5	19	<8	40	<5	<5
February	1.13	1.54	1.51	<5	18	<8	42	<5	<5
March	1.14	1.53	1.53	5	15	<8	45	<5	<5
April	1.17	1.48	1.48	<5	21	<8	45	<5	<5
May	1.15	1.60	1.53	7	23	<8	44	<5	<5
June	1.16	1.53	1.40	12	19	10	42	<5	7

[a] A, gamma-ray analysis.
[b] B, chemical analysis.
[c] "Less than" sign (<) indicates values were below detectable limits.
NA, no analysis.

-19-

tium-89, strontium-90, and barium-140 concentrations are determined radiochemically using ion exchange procedures. Chemical analyses are also made for stable calcium and potassium.

The Chattanooga milk sample is monitored by both the State and the Public Health Service's Southeastern Radiological Health Laboratory. This dual examination of aliquot samples provides a cross check between the two laboratories.

Results

The monthly averages of stable element and radionuclide concentrations in Tennessee pasteurized milk are presented in tables 3 to 5 for the period of July 1965 through June 1966.

---

3. Texas Milk Network
October-December 1966

Texas State Department of Health[3]

The Texas State Department of Health initiated a statewide milk sampling network for radionuclide content in April 1964. At present, monthly samples of raw milk are collected from each of seven "active" sampling points. In addition, six "standby" stations are collecting raw milk samples once each calendar quarter. The station locations shown in figure 4 were chosen to give maximum geographical and population coverage.

Samples are routinely analyzed for strontium-89 strontium-90 concentrations by a chemical separation technique employing ion exchange columns (*3*). Prepared samples are counted for 100 minutes in a low-background beta-particle counter.

Potassium-40, iodine-131, cesium-137, and barium-140 concentrations are determined by gamma-ray scintillation spectrometry. The procedure employs a 4- by 4-inch sodium iodide crystal and a 400-channel analyzer. Samples

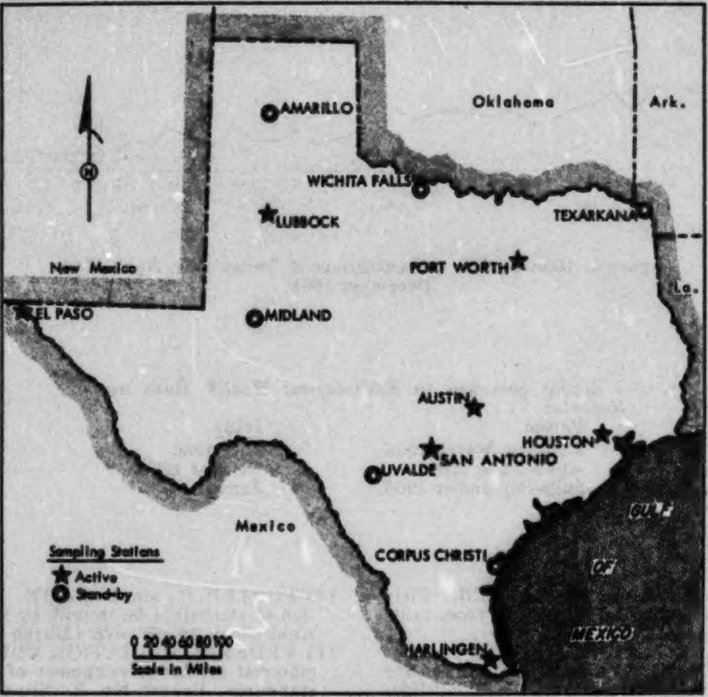

N
AMARILLO
Oklahoma
Ark.
WICHITA FALLS
LUBBOCK
TEXARKANA
New Mexico
FORT WORTH
La.
EL PASO
MIDLAND
AUSTIN
HOUSTON
SAN ANTONIO
UVALDE
GULF OF MEXICO
Mexico
Sampling Stations
Active
Stand-by
CORPUS CHRISTI
0 20 40 60 80 100
Scale in Miles
HARLINGEN

Figure 3. Texas milk sampling stations

---

[3] Acknowledgment is accorded to the staff of the Radiation Control Program, Division of Occupational Health and Radiation Control, under the direction of Mr. Martin C. Wukasch, chief engineer.

- 20 -

are counted for 100 minutes in a 3.5-liter Marinelli beaker. The matrix method of calculation is used and detection limits at the 95-percent confidence level are 10 pCi/liter.

Results

Potassium-40, strontium-90, iodine-131, and cesium-137 results by station and month for October through December 1966 are presented in table 6. During this time, the strontium-89 concentration was below the limit of detectability (5 pCi/liter). A summary of radionuclide concentrations in Texas milk for the period April 1964 to December 1966 is presented in figure 4.

Comparison of the observed radionuclide concentrations with the Federal Radiation Council guides for peacetime operation indicates that at no time during the period of surveillance did the radionuclide concentrations in Texas milk approach levels suggesting any remedial action (*4*).

Table 6. Radionuclide concentrations in Texas milk, network October–December 1966

Sampling location	Potassium-40 (pCi/liter)			Strontium-90 (pCi/liter)		
	Oct	Nov	Dec	Oct	Nov	Dec
Austin	1,280	1,230	1,280	5	8	4
Fort Worth	NS	1,220	1,390	NS	8	8
El Paso	1,230	1,310	1,230	4	4	4
Harlingen	1,360	1,400	1,360	3	6	3
Houston	1,230	1,310	1,420	15	17	11
Lubbock	1,220	1,310	1,300	4	8	5
San Antonio	1,240	1,380	1,270	5	5	5
Average	1,300	1,300	1,280	6	7	6

	Iodine-131 (pCi/liter)			Cesium-137 (pCi/liter)		
	Oct	Nov	Dec	Oct	Nov	Dec
Austin	ND	20	<10	10	10	10
Fort Worth	NS	10	ND	NS	5	5
El Paso	ND	<10	ND	10	10	10
Harlingen	<10	20	<10	10	5	10
Houston	ND	30	<10	20	20	20
Lubbock	ND	<10	ND	10	5	10
San Antonio	<10	10	ND	5	10	10
Average	<10	15	<10	11	9	11

NS, no sample.
ND, non detectable.

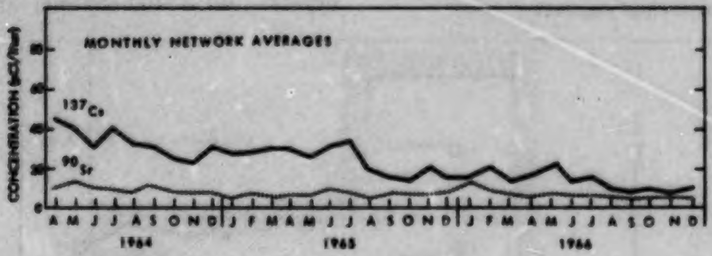


Figure 4. Radionuclide concentrations in Texas milk, April 1964–December 1966

Recent coverage in *Radiological Health Data and Reports*:

Period	Issue
January–March 1966	July 1966
April–June 1966	October 1966
July–September 1966	January 1967

REFERENCES

(*1*) PORTER, C. R., and M. W. CARTER. Field method for rapid collection of iodine-131 from milk. Public Health Rep 80:453–456 (May 1965).

(*2*) PORTER, C. R., R. J. AUGUSTINE, J. M. MATUSEK, JR., and M. W. CARTER. Procedures for Determination of Stable Elements and Radionuclides in Environmental Samples, PHS Publication 999-RH-10 (January 1965).

(*3*) PORTER, C., and B. KAHN. Improved determination of strontium-90 in milk by ion-exchange method. Anal Chem 36:676–678 (March 1964).

(4) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (September 1961).

FOOD AND DIET SURVEILLANCE ACTIVITIES

Efforts are being made by various Federal and State agencies to estimate the dietary intake of selected radionuclides on a continuous basis. These estimates, along with the guidance developed by the Federal Radiation Council, provide a basis for evaluating the significance of radioactivity in foods and diet.

Networks presently in operation and reported routinely include: (1) the Public Health Service's Institutional Total Diet Sampling Network, (2) the Atomic Energy Commission's Tri-City Diet Study, (3) the Food and Drug Administration's Teenage Diet Study, (4) the State of California's Diet Study, and (5) the State of Connecticut's Standard Diet Study. These networks provide data useful for developing estimates of nationwide dietary intakes of radionuclides. Periodically, results from the United Kingdom Diet Survey, conducted by the United Kingdom Agricultural Research Council Radiological Laboratory, are presented for comparison with data observed in the United States. Programs most recently reported in *Radiological Health Data and Reports* and not covered in this issue are listed below:

Program	Period reported	Last presented
California Diet	January-April 1966	January 1967
Connecticut Standard Diet	July 1965-June 1966	November 1966
Teenage Diet, FDA	February-November 1965	August 1966
Tri-City Diet, HASL	1965 Results (Cesium-137)	March 1967
United Kingdom Diet	Annual summary 1965	December 1966

---

1. Radionuclides in Institutional Diet Samples July-September 1966

National Center for Radiological Health
Public Health Service

The determination of radionuclide concentrations in the diet constitutes an important element of an integrated program of environmental radiation surveillance and assessment. In recognition of the potential significance of the diet in contributing to total environmental radiation exposures, the Public Health Service initiated its Institutional Diet Sampling Program in 1961. This program is administered by the National Center for Radiological Health with the assistance of the National Center for Urban and Industrial Health (*1*).

The program was designed to estimate the dietary intake of radionuclides in a selected population group ranging from children to young adults of school age. Initially, the program was conducted at eight institutions; as of January 1965, its scope had increased to boarding schools or institutions in 50 municipalities. These institutions ranged from financially well-to-do boarding schools to orphanages with severe economic limitations.

Subsequent experience with the diets of school children of various ages indicated that the number of institutions sampled could be selectively reduced. As of July 1965, 21 institutions, distributed geographically as shown in figure 1, were being sampled. Previous results showed that the daily intakes of teenage girls and children from 9 to 12 years of age was comparable, while teenage boys consumed 20 percent more food per day (*1,2*). Consequently, estimates for teenage boys and/or girls can be calculated on the basis of the dietary intakes of children.

In general, the sampling procedure is the same at each institution. Each sample supplied monthly by each institution represents the edible portion of the diet for a full 7-day week (21 meals plus soft drinks, candy bars, or other in-between snacks), obtained by duplicating the meals of a different individual each day. Drinking water, not included in the samples, is also sampled periodically. Each daily sample is kept frozen until the end of the collection period, and is then packed in dry ice and shipped by air express to either the Southwestern Radiological Health Laboratory, Las Vegas, Nev.; the Southeastern Radiological Health Laboratory, Montgomery, Ala.; or the Northeastern Radiological Health Laboratory; Winchester, Mass.

Table 1. Stable element and radionuclide concentrations in institutional total diets of children (9-12 years of age)[a], July-September 1966

Location of institution		Month 1966	Stable element (g/kg of diet)		Radionuclide concentration (pCi/kg of diet)			
			Calcium	Potassium	Strontium-89	Strontium-90	Cesium-137	Radium-226
Alaska:	Palmer	July	0.8	1.3	<5	15	45	0.4
		Aug	.6	1.4	<5	12	25	1.7
		Sept	.6	1.3	<5	15	25	1.6
Ariz:	Phoenix	July	.6	1.3	<5	10	10	1.8
		Aug	.5	1.4	<5	4	20	1.0
		Sept	.6	1.3	<5	6	5	.7
Ark:	Little Rock	July	.5	1.6	<5	12	20	1.1
		Aug	.5	1.3	<5	15	15	1.4
		Sept	.4	1.3	NA	18	35	1.0
Calif:	Los Angeles	July	.7	1.3	<5	6	25	.9
		Aug	1.0	1.5	<5	6	20	9.4
		Sept	.8	1.3	<5	11	25	1.6
Colo:	Denver	July	.6	1.3	<5	8	20	.3
		Aug	.7	1.4	<5	8	25	.8
		Sept	.7	1.2	<5	11	40	.6
Del:	Wilmington	July	NS	NS	NS	NS	NS	NS
		Aug	.7	1.6	<5	10	25	.7
		Sept	.7	1.7	<5	10	25	.5
Fla:	Tampa	July	.5	1.8	<5	8	55	1.1
		Aug	.9	1.6	<5	12	75	1.8
		Sept	.8	1.7	NA	14	80	9.1
Hawaii:	Honolulu	July	.5	1.3	<5	3	25	.8
		Aug	.4	1.3	<5	3	20	1.3
		Sept	.6	1.3	<5	3	25	.6
Idaho:	Idaho Falls	July	1.3	1.5	<5	8	25	.5
		Aug	.8	1.4	<5	9	25	.8
		Sept	.8	1.6	<5	9	20	.6
Ill:	Chicago	July	.7	1.4	5	6	20	.6
		Aug	.7	1.5	<5	6	15	.5
		Sept	.7	1.5	<5	6	20	.5
Ky:	Louisville	July	NS	NS	NS	NS	NS	NS
		Aug	NS	NS	NS	NS	NS	NS
		Sept	.7	1.7	NA	13	15	1.1
La:	New Orleans	July	.8	1.6	<5	16	35	.7
		Aug	.8	1.6	<5	10	35	1.1
		Sept	.7	1.7	<5	16	35	1.0
Mass:	Boston	July	.6	1.6	<5	9	20	.3
		Aug	NS	NS	NS	NS	NS	NS
		Sept	.6	1.5	<5	8	25	.1
Mo:	St. Louis[b]	July						
		Aug						
		Sept						
Ohio:	Cleveland	July	.7	1.5	<5	7	20	.8
		Aug	.7	1.5	<5	7	20	.3
		Sept	.6	1.6	<5	9	20	.7
Pa:	Pittsburgh	July	.5	1.6	<5	12	20	.6
		Aug	.6	1.4	<5	9	20	.4
		Sept	.5	1.4	<5	9	15	.6
S.C:	Charleston	July	.6	1.2	<5	12	35	1.3
		Aug	.6	1.4	<5	14	30	1.1
		Sept	.7	1.2	<5	14	40	1.1
S. Dak:	Sioux Falls	July	.9	1.5	5	13	25	.7
		Aug	NS	NS	NS	NS	NS	NS
		Sept	NS	NS	NS	NS	NS	NS
Tex:	Austin	July	.5	1.1	<5	7	15	.9
		Aug	.6	1.2	<5	8	15	1.3
		Sept	.4	1.1	NA	7	10	.9
Vt:	Burlington	July	.7	1.8	<5	15	45	.4
		Aug	.6	1.3	<5	7	40	.6
		Sept	.5	1.4	<5	9	20	.4
Wash:	Seattle	July	.8	1.5	<5	15	40	.2
		Aug	NS	NS	NS	NS	NS	NS
		Sept	.8	1.5	<5	15	40	1.1
Institutional average		July	0.7	1.4	<5	10	20	0.7
		Aug	0.8	1.4	<5	9	20	1.1
		Sept	0.6	1.4	<5	11	30	0.9

[a] Iodine-131 and barium-140 concentrations were below detectable levels for this period.
[b] Institution in St. Louis, Mo., discontinued collecting samples as of July 1, 1966. New school will enter the network in November 1966.
NA, no analyses.
NS, no sample.

A detailed description of sampling and analytical procedures was presented previously (*3*).

Results

Table 1 presents the analytical results for for institutional diet samples collected from July through September 1966, for children 9 to 12 years of age. The stable elements, calcium and potassium, are reported in g/kg of diet, and the radionuclide concentrations of strontium-89, strontium-90, cesium-137, and radium-226 are expressed as pCi/kg of diet. The reported radionuclide concentrations of these samples are corrected for radioactive decay to the midpoint

Table 2. Intake of stable elements and radionuclides in institutional total diet for children (9–12 years of age), July–September 1966

Location of institution	Month 1966	Total weight (kg/day)	Stable element intake (g/day)		Radionuclide intake (pCi/day)			
			Calcium	Potassium	Strontium-89	Strontium-90	Cesium-137	Radium-226
Alaska: Palmer	July [a]	1.60	1.3	2.1	5	24	70	0.6
	Aug	1.60	1.0	2.3	5	19	55	2.7
	Sept	1.67	1.0	2.0	5	15	60	2.7
Ariz: Phoenix	July	1.90	1.3	2.4	5	20	20	3.6
	Aug	1.64	.8	2.3	5	7	35	1.6
	Sept	1.49	1.3	1.8	5	9	5	1.0
Ark: Little Rock	July	2.18	1.0	3.3	5	37	40	2.3
	Aug	2.07	1.0	2.7	5	30	30	2.9
	Sept	1.17	.8	1.5	NA	21	25	1.3
Calif: Los Angeles	July	1.76	1.3	2.1	5	10	45	1.6
	Aug	2.08	2.1	3.1	5	12	40	4.9
	Sept [b]	1.91	1.8	2.3	5	21	50	3.1
Colo: Denver	July	2.10	1.8	2.5	5	17	40	1.3
	Aug	2.00	1.4	2.8	5	16	50	1.6
	Sept	2.04	1.4	2.4	5	22	40	1.2
Del: Wilmington	July	NS	NS	NS	NS	NS	NS	NS
	Aug	2.68	1.4	3.3	5	20	50	1.4
	Sept	2.05	1.4	3.5	5	20	50	1.0
Fla: Tampa	July [b]	1.76	.9	2.6	5	14	95	1.9
	Aug [b]	2.36	1.4	3.6	5	27	170	4.0
	Sept	2.10	1.3	2.6	NA	29	170	4.4
Hawaii: Honolulu	July [b]	1.98	1.0	2.5	5	6	70	1.0
	Aug [b]	2.10	.8	2.7	5	8	65	2.7
	Sept	2.08	1.7	2.5	5	6	50	1.2
Idaho: Idaho Falls	July [b]	1.60	2.2	2.5	5	10	40	.8
	Aug [b]	2.20	1.8	3.2	5	21	80	1.8
	Sept [b]	2.32	1.9	4.2	5	21	70	1.3
Ill: Chicago	July	1.43	1.0	2.0	5	9	30	.7
	Aug	1.30	1.0	2.0	5	8	20	.7
	Sept [b]	1.75	1.2	2.6	5	10	35	.9
Ky: Louisville	July	NS	NS	NS	NS	NS	NS	NS
	Aug	NS	NS	NS	NS	NS	NS	NS
	Sept [b]	1.75	1.2	3.0	NA	22	25	2.0
La: New Orleans	July	2.08	1.0	3.1	5	23	70	1.4
	Aug	1.80	1.3	2.4	5	29	55	1.7
	Sept	1.33	.9	2.3	5	21	45	1.2
Mass: Boston	July	1.92	1.2	3.1	5	17	60	.6
	Aug	NS	NS	NS	NS	NS	NS	NS
	Sept	1.64	1.0	2.5	5	13	40	.2
Mo: St. Louis [c]	July							
	Aug							
	Sept							
Ohio: Cleveland	July	1.22	.9	2.0	5	9	35	1.0
	Aug	1.52	1.1	2.3	5	11	30	.5
	Sept	1.16	.7	1.9	5	10	25	.8
Pa: Pittsburgh	July	2.33	1.2	2.7	5	28	45	1.4
	Aug	2.28	1.3	3.1	5	30	45	.9
	Sept	2.25	1.1	3.2	5	30	35	1.8
S.C.: Charleston	July	1.43	.9	1.9	5	17	50	1.9
	Aug [b]	1.63	1.0	2.3	5	23	50	1.8
	Sept	1.47	1.0	1.9	5	21	60	1.6
S. Dak: Sioux Falls	July	1.79	1.6	2.7	10	23	65	1.3
	Aug	NS	NS	NS	NS	NS	NS	NS
	Sept	NS	NS	NS	NS	NS	NS	NS
Tex: Austin	July	1.86	.9	2.1	5	13	30	1.7
	Aug	1.50	.9	1.8	5	12	30	2.0
	Sept	2.08	.8	2.3	NA	15	30	1.9
Vt: Burlington	July	1.33	.9	2.4	5	20	60	.5
	Aug	1.17	.7	1.5	5	8	45	.7
	Sept	1.24	.6	1.7	5	11	25	.5
Wash: Seattle	July	1.68	1.3	2.5	5	25	65	.3
	Aug	NS	NS	NS	NS	NS	NS	NS
	Sept [b]	1.72	1.4	2.6	5	26	70	1.9
Institutional average	July	1.79	1.1	2.6	5	19	45	1.5
	Aug	1.75	1.2	2.5	5	15	40	1.6
	Sept	1.70	1.0	2.4	5	17	50	1.8

[a] Data for this month were not used in the average because food samples were collected from two or more children under nine years of age.
[b] Data for this month were not used in average because food samples were collected from two or more children who were over 12 years of age.
[c] Institution in St. Louis, Mo., discontinued collecting samples as of July 1, 1966. New school will enter the network in November 1966.
NA, no analysis.
NS, no sample.

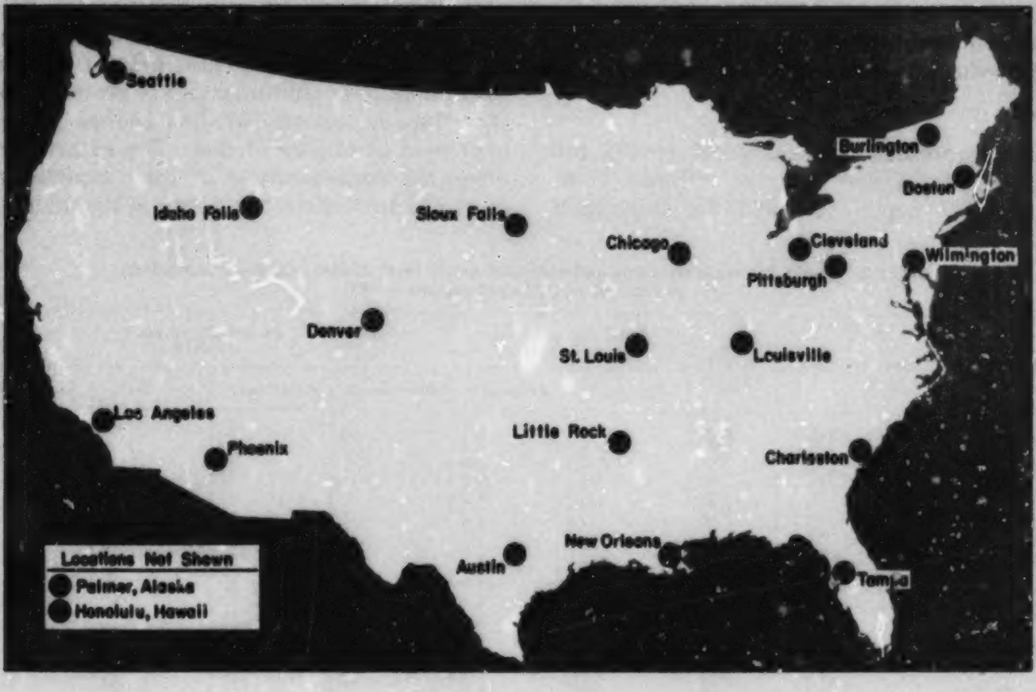

Seattle
Idaho Falls
Sioux Falls
Chicago
Burlington
Boston
Cleveland
Wilmington
Pittsburgh
Denver
St. Louis
Louisville
Los Angeles
Phoenix
Little Rock
Charleston
New Orleans
Austin
Tampa
Locations Not Shown
Palmer, Alaska
Honolulu, Hawaii

Figure 1. Current institutional diet sampling locations

of the sample collection period, where applicable.

Dietary intakes, presented in table 2, were obtained by multiplying the food consumption rate in kg/day by the concentration values given in table 1. For the purpose of obtaining dietary intakes, "less than" 5 pCi/kg of strontium-89 was interpreted as 2.5 pCi/kg. The average food consumption rate during this period was 1.75 kg/day compared to the network average of 1.90 kg/day observed from 1961 through 1964 (*4*).

Strontium-90 dietary intake during this period averaged 17 pCi/day. This result falls within Range I as defined by the Federal Radiation Council (*5*). Cesium-137 intakes average 45 pCi/day during this period. Strontium-89, iodine-131, and barium-140 concentrations were generally below detectable levels.

REFERENCES

(*1*) ANDERSON, E. C., and D. J. NELSON, JR. Surveillance for radiological contamination in foods. Amer J Public Health 52:1391–1400 (September 1962).

(*2*) PUBLIC HEALTH SERVICE, DIVISION OF RADIOLOGICAL HEALTH. Radionuclides in institutional total diet samples, January–March 1965. Radiol Health Data 6:548–554 (October 1965).

(*3*) PUBLIC HEALTH SERVICE, DIVISION OF RADIOLOGICAL HEALTH. Radionuclides in institutional total diet samples, April–June 1965. Radiol Health Data Rep 7:92–98 (February 1966).

(*4*) GRUNDY, R. D., C. CALVERT, and A. G. BERGER. Summary of results of Institutional Total Diet Sampling Network, 1961–1964. Radiol Health Data 6:691–698 (December 1965).

(*5*) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, Report No. 2. Superintendent of Documents U.S. Government Printing Office, Washington, D.C. 20402 (September 1961).

Recent coverage in *Radiological Health Data and Reports*:

Period	Issue
1965 annual averages	July 1966
January–March 1966	October 1966
April–June 1966	January 1967

Section II. Water

The Public Health Service, the Federal Water Pollution Control Administration, and other Federal, State, and local agencies operate extensive water quality sampling and analysis programs for surface, ground, and treated water. Most of these programs include determinations of gross beta and gross alpha radioactivity and specific radionuclides.

Although the determination of the total radionuclide intake from all sources is of primary importance, a measure of the public health importance of radioactivity levels in water can be obtained by comparison of the observed values with the Public Health Service Drinking Water Standards (*1*). These Standards, based on consideration of Federal Radiation Council (FRC) recommendations (*2–4*), set the limits for approval of a drinking water supply containing radium-226 and strontium-90 as 3 pCi/liter and 10 pCi/liter, respectively. Limits may be higher if total intake of radioactivity from all sources indicates that such intakes are within the guides recommended by FRC for control action. In the known absence[1] of strontium-90 and alpha-particle emitters, the limit is 1,000 pCi/liter gross beta radioactivity, except when more complete analysis indicates that concentrations of radionuclides are not likely to cause exposures greater than the Radiation Protection Guides. Surveillance data from a number of Federal and State programs are published periodically to show current and long-range trends. Water programs previously reported in *Radiological Health Data and Reports* are listed below.

Program	Period reported	Last presented
California Water Sampling Program	July-December 1965	November 1966
Coast Guard Water Sampling Program	1965	November 1966
Colorado River Basin Sampling Network	1962-1964	November 1965
Drinking Water Analysis Program	1962	October 1965
Florida Water Sampling Program	1964	November 1966
Kentucky Water Sampling Program	May 1963-June 1964	March 1965
Lower Columbia River Radiological Survey in Oregon	August 1963-July 1964	October 1965
Minnesota Surface Water Sampling Program	July-December 1965	July 1966
New York Surface Water Sampling Program	June-December 1965	June 1966
North Carolina Water Sampling Program	1964	November 1965
Radiostrontium in Tap Water, HASL	November 1965-June 1966	December 1966
Washington Surface Water Sampling Program	July 1964-June 1965	May 1966

REFERENCES

(*1*) U.S. PUBLIC HEALTH SERVICE. Drinking water standards, revised 1962, PHS Publication No. 956. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (March 1963).

(*2*) FEDERAL RADIATION COUNCIL. Radiation Protection Guidance for Federal Agencies. Memorandum for the President, September 1961. Reprint from the Federal Register of September 26, 1961.

(*3*) FEDERAL RADIATION COUNCIL. Background material for the development of Radiation Protection Standards, Report No. 1. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (May 1960).

(*4*) FEDERAL RADIATION COUNCIL. Background material for the development of Radiation Protection Standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (September 1961).

---

[1] Absence is taken to mean a negligibly small fraction of the specific limits of 3 pCi/liter and 10 pCi/liter for unidentified alpha-particle emitters and strontium-90, respectively.

GROSS RADIOACTIVITY IN SURFACE WATERS OF THE UNITED STATES, OCTOBER 1966

Division of Pollution Surveillance
Federal Water Pollution Control Administration
Department of Interior

The monitoring of levels of radioactivity in surface waters of the United States was begun in 1957 as part of the Federal Water Pollution Control Administration's Water Pollution Surveillance System. Table 1 presents the current preliminary results of the alpha and beta particle analysis. The radioactivity associated with dissolved solids provides a rough indication of the levels which would occur in treated water, since nearly all suspended matter is removed by treatment processes. Strontium-90 results are reported semiannually. The stations on each river are arranged in the table according to their distance from the headwaters. Figure 1 indicates the average total beta radioactivity in suspended-plus-dissolved solids in raw water collected at each station. A description of the sampling and analytical procedures was published in the June 1966 issue of *Radiological Health Data and Reports*.

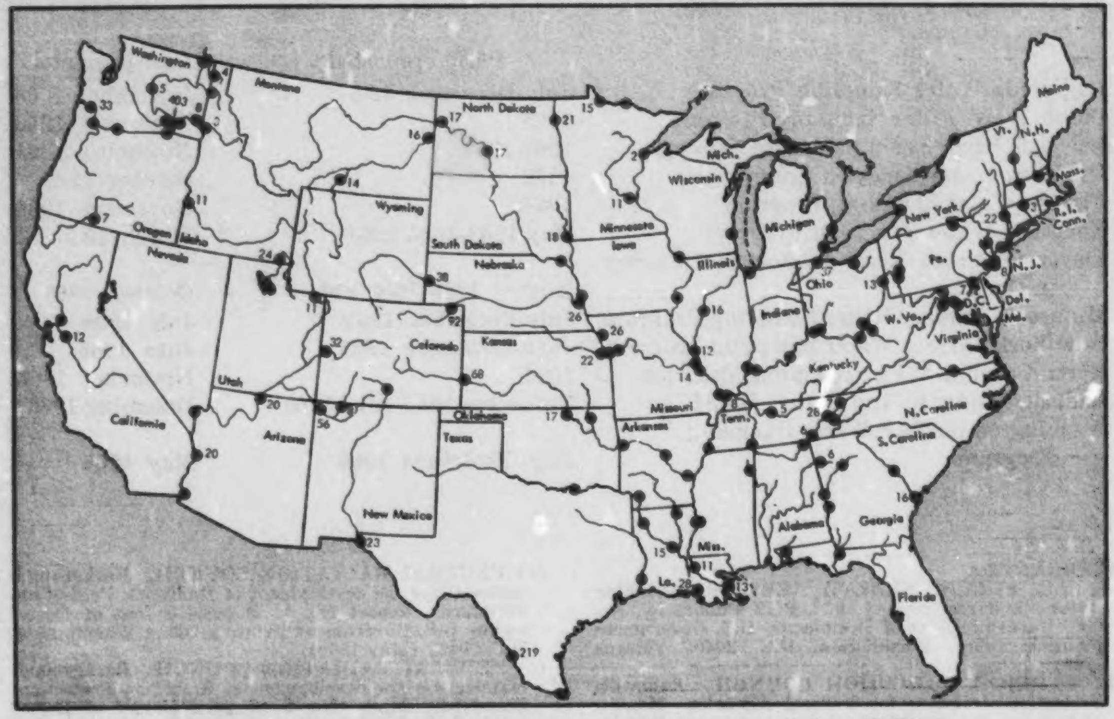

Washington
Montana
North Dakota
Minnesota
Wisconsin
Mich.
Michigan
Maine
Vt.
N.H.
Mass.
R.I.
Conn.
New York
Pa.
N.J.
Del.
Md.
D.C.
W. Va.
Virginia
Ohio
Indiana
Illinois
Iowa
Kentucky
Tenn.
N. Carolina
S. Carolina
Georgia
Alabama
Miss.
La.
Florida
Arkansas
Missouri
Oklahoma
Texas
Kansas
Nebraska
South Dakota
Wyoming
Colorado
New Mexico
Arizona
Utah
Nevada
California
Oregon
Idaho
33
5
403
8
4
3
7
11
12
24
14
16
17
17
21
15
2
11
18
38
92
26
26
22
32
68
20
20
56
17
23
219
16
12
14
8
5
7
26
6
6
16
15
11
28
13
37
13
22
3
7
8

Figure 1. Sampling locations and associated total beta radioactivity (pCi/liter) in surface waters, October 1966

Table 1. Radioactivity in raw surface waters, October 1966

Station	Average beta radioactivity (pCi/liter)			Average alpha radioactivity (pCi/liter)		
	Suspended	Dissolved	Total	Suspended	Dissolved	Total
Animas River:						
Cedar Hill, N. Mex.	<1	8	8	0	1	1
Arkansas River:						
Coolidge, Kans.	26	42	68	10	30	40
Ponca City, Okla.	2	15	17	0	0	0
Atchafalaya River:						
Morgan City, La.	13	15	28	5	1	6
Bear River:						
Preston, Idaho	1	23	24	0	1	1
Big Horn River:						
Hardin, Mont.	4	10	14	1	2	3
Big Sioux River:						
Sioux Falls, S. Dak.	4	14	18	1	2	3
Chena River:						
Fairbanks, Alaska	1	2	3	0	0	0
Clearwater River:						
Lewiston, Idaho	<1	3	3	0	0	0
Clinch River:						
Clinton, Tenn.	2	5	7	0	1	1
Kingston, Tenn.*	12	16	28	<1	1	1
Colorado River:						
Loma, Colo.	12	20	32	2	16	18
Page, Ariz.	0	20	20	0	5	5
Parker Dam, Calif-Ariz.	2	18	20	0	5	5
Columbia River:						
Wenatchee, Wash.	1	4	5	0	1	1
Pasco, Wash.*	40	363	403	0	<1	<1
Clatskanie, Ore.	6	27	33	0	0	0
Connecticut River:						
Enfield Dam, Conn.	0	2	2	0	0	0
Coosa River:						
Rome, Ga.	1	5	6	0	0	0
Cumberland River:						
Cheatham Lock, Tenn.	1	4	5	0	0	0
Delaware River:						
Philadelphia, Pa.	1	7	8	0	1	1
Great Lakes:						
Duluth, Minn.	0	2	2	0	0	0
Green River:						
Dutch John, Utah	1	10	11	0	2	2
Hudson River:						
Poughkeepsie, N.Y.	10	12	22	0	1	1
Illinois River:						
Peoria, Ill.	5	11	16	1	1	2
Grafton, Ill.	3	9	12	0	1	1
Kansas River:						
DeSoto, Kans.	7	15	22	1	0	1
Klamath River:						
Keno, Ore.	1	6	7	0	0	0
Maumee River:						
Toledo, Ohio	10	27	37	0	1	1
Mississippi River:						
St. Paul, Minn.	0	11	11	0	0	0
E. St. Louis, Ill.	3	11	14	0	1	1
New Roads, La.	1	10	11	0	1	1
New Orleans, La.	1	12	13	0	3	3
Missouri River:						
Williston, N. Dak.	4	13	17	0	2	2
Bismarck, N. Dak.	2	15	17	0	2	2
St. Joseph, Mo.	9	17	26	2	3	5
North Platte River:						
Henry, Nebr.	2	36	38	<1	25	25
Ohio River:						
Toronto, Ohio	1	12	13	0	0	0
Cairo, Ill.	2	6	8	0	0	0
Pend Oreille River:						
Albeni Falls Dam, Idaho	1	3	4	0	1	1
Platte River:						
Plattsmouth, Nebr.	8	18	26	2	5	7
Rainy River:						
Baudette, Minn.	2	13	15	0	0	0
Red River, North:						
Grand Forks, N. Dak.	0	21	21	0	1	1
Red River, South:						
Alexandria, La.	3	12	15	1	1	2
Rio Grande:						
El Paso, Tex.	2	21	23	0	3	3
Laredo, Tex.	201	18	219	70	4	74
San Joaquin River:						
Vernalis, Calif.	3	9	12	1	6	7
San Juan River:						
Shiprock, N. Mex.	45	11	56	14	3	17
Savannah River:						
Port Wentworth, Ga.*	3	13	16	0	0	0
Snake River:						
Payette, Idaho	2	9	11	0	4	4
Wawawai, Wash.	1	7	8	0	1	1
South Platte River:						
Julesburg, Colo.	13	79	92	2	48	50
Susquehanna River:						
Conowingo, Md.	1	6	7	0	0	0
Tennessee River:						
Chattanooga, Tenn.	3	3	6	<1	0	<1
Yellowstone River:						
Sidney, Mont.	5	11	16	1	4	5
Maximum	201	363	403	70	48	74
Minimum	0	2	2	0	0	0

* Gross beta radioactivity at this station may not be directly comparable to gross beta radioactivity at other stations because of the possible contribution of radionuclides from an upstream nuclear facility in addition to the contribution from fallout and naturally occurring radionuclides common to all stations.

Complete data and exact sampling locations for 1958 through 1963 are published in annual compilations (*1–6*). Detailed data for subsequent years are available on request.

Special note is taken when the alpha radic activity is 15 pCi/liter or greater or when the beta radioactivity is 150 pCi/liter or greater. These arbitrary levels provide a basis for the selection of certain data and for comment on the data, if needed. They reflect no public health significance as the Public Health Service drinking water standards have already provided the basis for this assessment. Changes from or toward these arbitrary levels are also noted in terms of changes in radicactivity per unit weight of solids. No discussion of gross radioactivity per gram of dissolved or suspended solids for all stations of the Water Pollution Surveillance System will be attempted at this time. Comments are made only on monthly average values. Occasional high values from single weekly samples may be absorbed into a relatively low average. When these values are significantly high, comment is made. During both September and October, the following stations showed alpha radioactivity in excess of 15

-28-

pCi/liter on either dissolved or suspended solids:

Arkansas River: Coolidge, Kans.
Colorado River: Loma, Colo.
North Platte River: Henry, Nebr.
Rio Grande: Laredo, Tex.
South Platte River: Julesburg, Colo.

The beta radioactivity on suspended solids was greater than 150 pCi/liter for Laredo, Tex., on the Rio Grande. This high value was entirely due to the high solids loading for two samples during this month. On the Columbia River at Pasco, Wash., the beta radioactivity on dissolved solids showed an average of over 150 pCi/liter.

REFERENCES

(*1*) PUBLIC HEALTH SERVICE, DIVISION OF WATER SUPPLY AND POLLUTION CONTROL. National water quality network annual compilation of data, PHS Publication No. 663, 1958 Edition. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

(*2*) *Ibid.*, 1959 Edition.

(*3*) *Ibid.*, 1960 Edition.

(*4*) *Ibid.*, 1961 Edition.

(*5*) *Ibid.*, 1962 Edition.

(*6*) PUBLIC HEALTH SERVICE, DIVISION OF WATER SUPPLY AND POLLUTION CONTROL. Water pollution surveillance system, annual compilation of data, PHS Publication No. 663 (Revised), 1963 Edition. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

Section III. Air and Deposition

RADIOACTIVITY IN AIRBORNE PARTICULATES AND PRECIPITATION

Continuous surveillance of radioactivity in air and precipitation provides one of the earliest indications of changes in environmental fisson product activity. To date, this surveillance has been confined chiefly to gross beta-particle analysis. Although such data are insufficient to assess total human radiation exposure from fallout, they can be used to determine when to modify monitoring in other phases of the environment.

Surveillance data from a number of programs are published monthly and summarized periodically to show current and long-range trends of atmospheric radioactivity in the Western Hemisphere. These include data from activities of the U.S. Public Health Service, the Canadian Department of National Health and Welfare, the Mexican Commission of Nuclear Energy, and the Pan American Health Organization.

An intercomparison of the above networks was performed by Lockhart and Patterson in 1962 and is summarized in the January 1964 issue of *Radiological Health Data*. In addition to the programs presented in this issue, the following programs were previously covered in *Radiological Health Data and Reports:*

Network	Period reported	Last presented
HASL Fallout Network	January-June 1966	March 1967
HASL 80th Meridian Network	Calendar year 1965	January 1967

---

1. Radiation Surveillance Network
December 1966

National Center for Radiological Health
Public Health Service

Surveillance of atmospheric radioactivity in the United States is conducted by the Radiation Surveillance Network (RSN), which regularly gathers samples from 74 stations distributed throughout the country (figure 1). Most of the stations are operated by State health department personnel.

Daily samples of airborne particulates and precipitation are forwarded to the National Center for Radiological Health, in Rockville, Md., for laboratory analysis. The alerting function of the network is provided by routine field estimates of the gross beta radioactivity made by the station operators prior to submission of the samples. When high air activity is reported. appropriate officials are promptly notified. Compilation of field estimates and laboratory confirmations are reported elsewhere on a monthly basis (*1*). A detailed description of the sampling and analysis procedures was presented in

Table 1. Gross beta radioactivity in surface air and precipitation, December 1966

Station location		Number of samples		Air surveillance gross beta radioactivity (pCi/m³)			Last profile in *RHD&R*	Precipitation	
		Air	Pptn	Maximum	Minimum	Average [a]		Total depth (mm)	Total deposition (nCi/m²)
Ala:	Montgomery	30	7	0.18	<0.10	<0.11	Nov 66	85	< 17
Alaska:	Adak	31	....	.22	< .10	< .11	June 66	(b)	
	Anchorage	14	3	.26	< .10	< .15	Dec 66	6	< 1
	Attu Island	28	....	.12	< .10	< .10	July 66	(b)	
	Fairbanks	22	1	< .10	< .10	< .10	Jan 67	4	< 1
	Juneau	18	11	.11	< .10	< .10	Feb 67	121	< 24
	Kodiak	14	....	.20	< .10	< .11	Mar 67	(b)	
	Nome	(c)	....	....	....	....	Sept 66	(b)	
	Pt. Barrow	28	....	.23	< .10	< .11	Aug 66	(b)	
	St. Paul Island	(c)	....	....	....	....	Oct 66	(b)	
Ariz:	Phoenix	30	....	.15	< .10	< .11	Feb 67	(b)	
Ark:	Little Rock	24	4	.15	< .10	< .10	Dec 66	97	< 19
Calif:	Berkeley	21	8	< .10	< .10	< .10	Mar 67	108	< 22
	Los Angeles	21	3	< .10	< .10	< .10	Sept 66	131	< 26
C.Z:	Ancón	17	....	< .10	< .10	< .10	Feb 67	(b)	
Colo:	Denver	30	1	.13	< .10	< .10	Mar 67	4	< 1
Conn:	Hartford	31	10	.13	< .10	< .10	Jan 67	57	< 12
Del:	Dover	30	....	.11	< .10	< .10	Nov 66	(b)	
D.C:	Washington	30	7	.23	< .10	< .11	Aug 66	93	< 19
Fla:	Jacksonville	31	4	.60	< .10	< .13	Dec 66	66	< 13
	Miami	29	4	.15	< .10	< .10	Jan 67	35	< 7
Ga:	Atlanta	21	3	.22	< .10	< .11	Oct 66	10	< 2
Guam:	Agana	31	....	< .10	< .10	< .10	Nov 66	(b)	
Hawaii:	Honolulu	30	6	< .10	< .10	< .10	July 66	82	< 16
Idaho:	Boise	26	7	< .10	< .10	< .10	July 66	25	< 5
Ill:	Springfield	30	5	.21	< .10	< .11	Aug 66	74	< 15
Ind:	Indianapolis	31	9	.20	< .10	< .11	Oct 66	127	< 25
Iowa:	Iowa City	31	8	.21	< .10	< .11	Feb 67	30	< 6
Kans:	Topeka	31	4	.18	< .10	< .11	Dec 66	8	< 2
Ky:	Frankfort	28	9	.16	< .10	< .11	Aug 66	55	< 11
La:	New Orleans	31	9	.14	< .10	< .11	Aug 66	137	< 28
Maine:	Augusta	30	11	.11	< .10	< .10	Sept 66	100	< 20
	Presque Isle	17	....	< .10	< .10	< .10	Feb 67	(b)	
Md:	Baltimore	21	5	.15	< .10	< .11	Jan 67	45	< 9
	Rockville	17	....	.13	< .10	< .10	July 66	(b)	
Mass:	Lawrence	29	8	.17	< .10	< .11	Nov 66	77	< 16
	Winchester	30	8	.12	< .10	< .10	Mar 67	69	< 14
Mich:	Lansing	30	....	.18	< .10	< .11	July 66	(b)	
Minn:	Minneapolis	21	6	.16	< .10	< .10	Nov 66	18	< 4
Miss:	Jackson	30	6	.14	< .10	< .10	Sept 66	91	< 18
Mo:	Jefferson City	29	5	.15	< .10	< .10	Oct 66	56	< 11
Mont:	Helena	31	3	< .10	< .10	< .10	June 66	10	< 2
Nebr:	Lincoln	19	2	.90	< .10	< .11	Oct 66	21	<134
Nev:	Las Vegas	26	....	.12	< .10	< .10	Jan 67	(b)	
N.H:	Concord	18	....	.12	< .10	< .10	Aug 66	(b)	
N.J:	Trenton	31	6	.13	< .10	< .10	Sept 66	19	< 4
N. Mex:	Santa Fe	26	3	.13	< .10	< .10	June 66	13	< 3
N.Y:	Albany	21	10	.11	< .10	< .10	Oct 66	58	< 12
	Buffalo	19	....	.14	< .10	< .10	Feb 67	(b)	
	New York	31	....	.13	< .10	< .10	Mar 67	(b)	
N.C:	Gastonia	31	4	.21	< .10	< .11	Feb 67	50	< 10
N. Dak:	Bismarck	31	2	.19	< .10	< .11	Aug 66	4	< 1
Ohio:	Cincinnati	12	....	.19	< .10	< .11	Nov 66	(b)	
	Columbus	31	9	.24	< .10	< .12	Sept 66	68	< 14
	Painesville	30	15	.13	< .10	< .10	Jan 67	113	< 23
Okla:	Oklahoma City	23	5	< .10	< .10	< .10	July 66	13	< 3
	Ponca City	28	3	< .10	< .10	< .10	Jan 67	16	< 3
Ore:	Portland	30	19	< .10	< .10	< .10	Oct 66	124	< 25
Pa:	Harrisburg	30	2	.11	< .10	< .10	Oct 66	24	< 5
P.R:	San Juan	30	7	.22	< .10	< .10	Sept 66	195	< 39
R.I:	Providence	28	7	< .10	< .10	< .10	July 66	56	< 11
S.C:	Columbia	29	8	.15	< .10	< .10	Mar 67	77	< 15
S. Dak:	Pierre	30	....	.14	< .10	< .10	Feb 67	(b)	
Tenn:	Nashville	31	8	.16	< .10	< .10	July 66	119	< 24
Tex:	Austin	31	5	.13	< .10	< .10	Nov 66	20	< 4
	El Paso	31	....	.13	< .10	< .10	Aug 66	(b)	
Utah:	Salt Lake City	30	7	.19	< .10	< .10	Sept 66	21	< 4
Vt:	Barre	30	13	.13	< .10	< .10	Dec 66	78	< 16
Va:	Richmond	31	8	.12	< .10	< .10	Dec 66	58	< 12
Wash:	Seattle	29	20	< .10	< .10	< .10	Dec 66	128	< 27
	Spokane	31	8	< .10	< .10	< .10	Nov 66	54	< 11
W. Va:	Charleston	31	12	.18	< .10	< .10	Mar 67	57	< 11
Wis:	Madison	30	7	.14	< .10	< .10	Dec 66	72	< 14
Wyo:	Cheyenne	31	1	.12	< .10	< .10	Jan 67	2	< 1
Network summary		1,034	366	0.60	<0.10	<0.10	....	61	< 15

[a] The monthly average is calculated by weighting the individual samples with length of sampling period. Values of <0.10 are assumed to be 0.10 for averaging purposes. If 10 percent or more samples from a station contain <0.10 pCi/m³, a less-than sign is placed before the average.

[b] No precipitation sample collected.

[c] No report received.

-31-

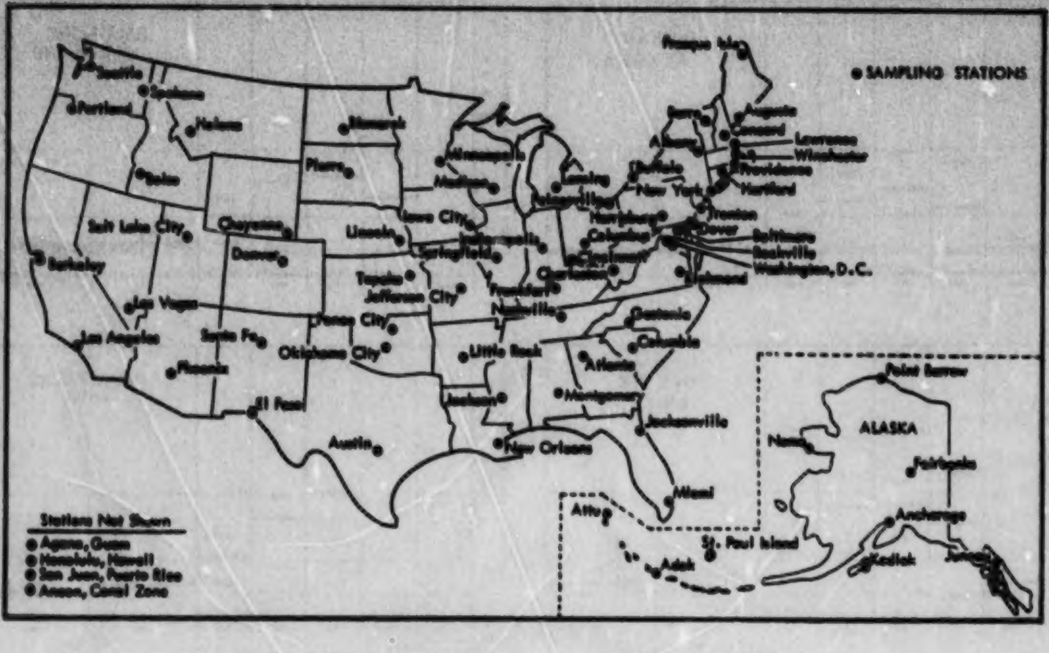

Presque Isle
SAMPLING STATIONS
Seattle
Spokane
Portland
Helena
Bismarck
Boise
Pierre
Minneapolis
Madison
Lansing
Salt Lake City
Cheyenne
Lincoln
Iowa City
Indianapolis
Springfield
Denver
Berkeley
Topeka
Jefferson City
Frankfort
Las Vegas
Dodge City
Nashville
Los Angeles
Santa Fe
Oklahoma City
Little Rock
Phoenix
El Paso
Jackson
Montgomery
Atlanta
Austin
New Orleans
Barre
Augusta
Concord
Albany
Lawrence
Winchester
Buffalo
Providence
New York
Hartford
Harrisburg
Trenton
Columbus
Dover
Baltimore
Rockville
Washington, D.C.
Charleston
Richmond
Gastonia
Columbia
Jacksonville
Miami
Point Barrow
ALASKA
Nome
Fairbanks
Attu
Anchorage
St. Paul Island
Adak
Kodiak
Juneau
Stations Not Shown
● Agana, Guam
● Honolulu, Hawaii
● San Juan, Puerto Rico
● Ancon, Canal Zone

Figure 1. Radiation Surveillance Network sampling stations

the November 1966 issue of *Radiological Health Data and Reports*.

Table 1 presents the monthly average gross beta radioactivity in surface air and deposition by precipitation during December 1966. Time profiles of gross beta radioactivity in air for eight RSN stations are shown in figure 2.

Gross beta radioactivity in December air samples have decreased to levels slightly above those existing prior to the Chinese mainland test of October 27, 1966, EST. The most active sample was collected at Lincoln, Nebr., on December 28, 1966, and measured 0.90 pCi/m^3 on January 5, 1967. The only other sample more active than 0.3 pCi/m^3 was the December 2, 1966, Jacksonville, Fla., sample, which measured 0.6 pCi/m^3.

A total of 311 network air samples were gamma-scanned in December, and fresh fission products were identified on the air samples listed in table 2.

Table 2. Fresh fission products identified in RSN air samples, December 1966

Location		Date December 1966
Alaska:	Anchorage	1
	Point Barrow	29, 30, 31
Ga:	Atlanta	2
Nebr:	Lincoln	28

Precipitation radioactivity levels, with one exception, were at or near minimum reporting levels. Only seven samples were more active than 200 pCi/liter. The most active precipitation sample, and the only one to exceed 400 pCi/liter, was collected at Lincoln, Nebr., on December 28, 1966, contained 511,500 pCi/liter at the time of collection, and represented a deposition of 133.4 nCi/m^2 of gross beta radioactivity. The presence of fresh fission products was confirmed in this sample by gamma-ray spectrometry.

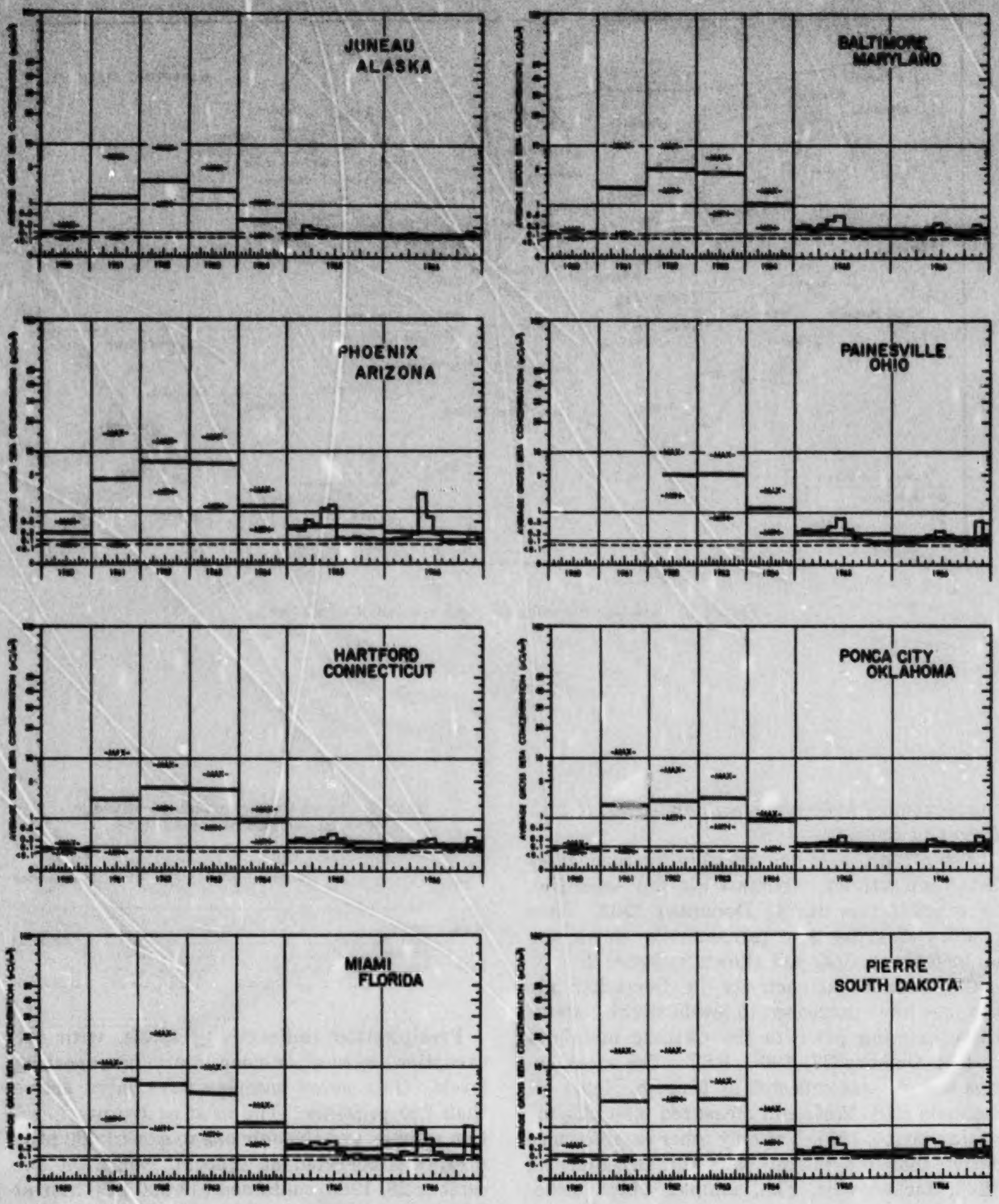


Figure 2. Monthly and yearly profiles of beta radioactivity in air—Radiation Surveillance Network, 1960–December 1966

-33-

2. Canadian Air and Precipitation Monitoring Program December 1966[1]

Radiation Protection Division
Department of National Health and Welfare

The Radiation Protection Division of the Canadian Department of National Health and Welfare monitors surface air and precipitation in connection with its Radioactive Fallout Study Program. Twenty-four collection stations are located at airports where the sampling equipment is operated by personnel from the Meteorological Services Branch of the Department of Transport (figure 3), Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports of the Department of National Health and Welfare (*2–6*).

A summary of the sampling procedures and methods of analysis was presented in the November 1966 issue of *Radiological Health Data and Reports.*

Surface air and precipitation data for December 1966 are presented in table 3.

Table 3. Canadian gross beta radioactivity in surface air and precipitation, December 1966

Station	Number of samples	Air surveillance radioactivity (pCi/m³)			Precipitation measurements	
		Maximum	Minimum	Average	Average concentrations (pCi/liter)	Total deposition (nCi/m²)
Calgary	31	0.2	0.0	0.1	9,077	36.9
Coral Harbour	31	.2	.0	.1	88	.3
Edmonton	31	.2	.0	.1	205	2.7
Ft. Churchill	31	.2	.0	.1	7	.2
Ft. William	31	.2	.0	.1	14	.5
Fredericton	29	.2	.0	.1	4	.3
Goose Bay	31	.2	.0	.1	9	1.2
Halifax	31	.2	.0	.1	3	.4
Inuvik	31	.2	.0	.1	14	.3
Montreal	22	.2	.0	.1	7	7
Moosonee	30	.1	.0	.1	NS	NS
Ottawa	30	.2	.0	.1	9	1.1
Quebec	31	.2	.0	.1	10	1.0
Regina	31	.2	.0	.1	47	.5
Resolute	31	.2	.0	.1	41	.2
St. John's, Nfld	31	.2	.0	.0	5	1.2
Saskatoon	31	.2	.0	.1	24	.3
Sault Ste. Marie	30	.2	.0	.1	8	.6
Toronto	30	.2	.0	.1	6	.6
Vancouver	31	.1	.0	.0	17	4.2
Whitehorse	31	.2	.0	.1	532	2.7
Windsor	31	.2	.0	.1	10	1.2
Winnipeg	31	.2	.0	.1	219	4.6
Yellowknife	30	.2	.0	.1	11	.2
Network summary		0.2	0.0	0.1	451	2.7

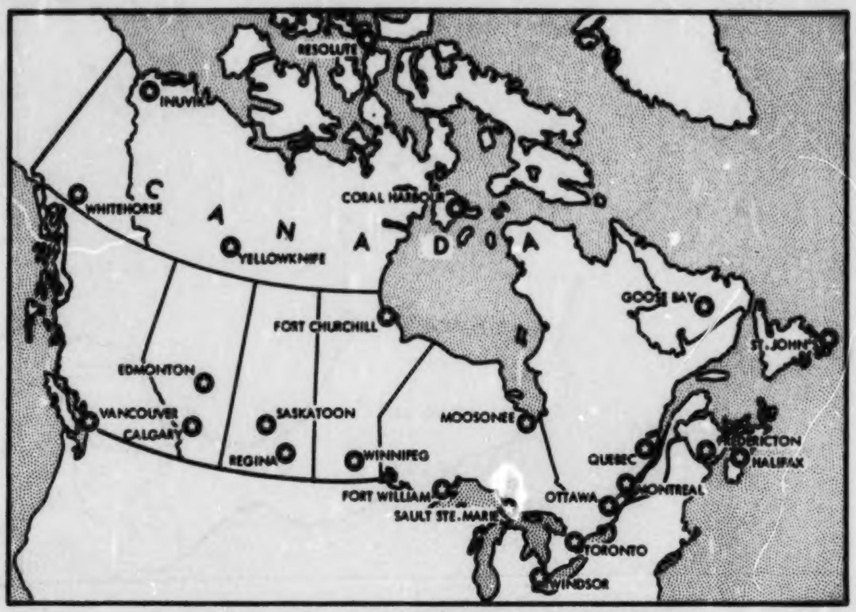

RESOLUTE
INUVIK
C
WHITEHORSE
A
N
A
D
A
CORAL HARBOUR
YELLOWKNIFE
GOOSE BAY
FORT CHURCHILL
ST. JOHN'S
EDMONTON
VANCOUVER
CALGARY
SASKATOON
MOOSONEE
REGINA
WINNIPEG
QUEBEC
FREDERICTON
HALIFAX
FORT WILLIAM
SAULT STE. MARIE
OTTAWA
MONTREAL
TORONTO
WINDSOR

Figure 3. Canadian air and precipitation sampling stations

---

[1] Prepared from information and data in the January 1967 monthly report "Data from Radiation Protection Program," Canadian Department of National Health and Welfare, Ottawa, Canada.

3. Mexican Air Monitoring Program
December 1966

National Commission of Nuclear Energy

The Radiation Surveillance Network of Mexico was established by the Comisión Nacional de Energía Nuclear (CNEN), México, D.F. From 1952 to 1961, the network was directed by the Institute of Physics of the University of Mexico, under contract to the CNEN.

In 1961, the CNEN appointed its Division of Radiological Protection to establish a new radiation surveillance network. In 1966, the Division of Radiological Protection was restructured and its name changed to Dirección General de Seguridad Radiológica (DRS). The network consists of 16 stations (figure 4), 11 of which are located at airports and operated by airline personnel. The remaining five stations are located at México, D.F., Mérida, Veracruz, San Luis Potosí, and Ensenada. Staff members of the DRS operate the station at México, D.F., while the other four stations are manned by members of the Centro de Previsión del Golfo de México, the Chemistry Department of the University of Mérida, the Instituto de Zonas Desérticas of the University of San Luis Potosí, and the Escuela Superior de Ciencias Marinas of the University of Baja California, respectively.

Sampling

The sampling procedure involves drawing air through a high-efficiency 6- by 9-inch glass-fiber filter for 20 hours a day, 3 or 4 days a week at the rate of 1,000 cubic meters per day using high-volume samplers.

After each 20-hour sampling period, the filter is removed and shipped via airmail to the Sección de Radioactividad Ambiental, CNEN, in México, D.F., for assay of gross beta radioactivity, allowing a minimum of 3 or 4 days after collection for the decay of radon and thoron. The data are not extrapolated to the time of collection. Statistically, it has been found that a minimum of eight samples per month were needed to get a reliable average activity at each station (7).

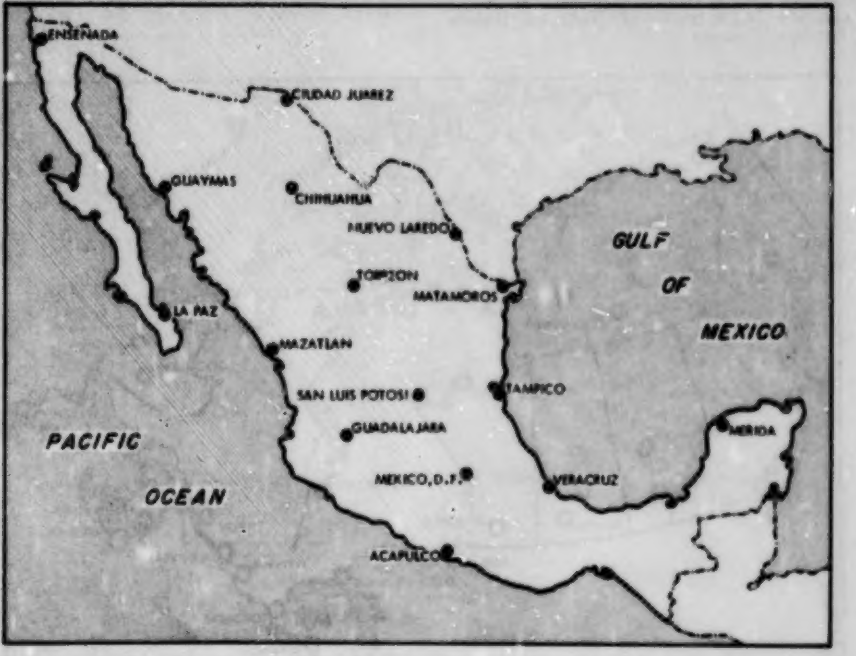


Figure 4. Mexican air sampling locations

The maximum, minimum, and average gross beta radioactivity in surface air during December 1966 are presented in table 4.

Table 4. Mexican gross beta radioactivity of airborne particulates, December 1966

Station	Number of samples	Gross beta radioactivity (pCi/m³)		
		Maximum	Minimum	Average
Acapulco	10	0.1	<0.1	0.1
Chihuahua	11	.1	.1	.1
Ciudad Juárez	12	.1	< .1	.1
Ensenada	15	.3	< .1	.1
Guadalajara	1	----------	----------	.1
Guaymas	1	----------	----------	< .1
La Paz	21	.1	< .1	.1
Matamoros	NS			
Mazatlán	9	.1	.1	.1
Mérida	17	.1	< .1	.1
México, D.F.	9	.1	.1	.1
Nuevo Laredo	6	.1	< .1	.1
San Luis Potosí	NS			
Tampico	NS			
Torreón	10	.2	.1	.1
Veracruz	9	.1	< .1	.1

NS, no sample collected, station temporarily shutdown.

4. Pan American Air Sampling Program December 1966

Pan American Health Organization and *U.S. Public Health Service*

Gross beta radioactivity in air is monitored by countries in the Americas under the auspices of the collaborative program developed by the Pan American Health Organization (PAHO) and the U.S. Public Health Service (PHS) to assist PAHO-member countries in developing radiological health programs. The sampling equipment and analytical services are provided by the National Center for Radiological Health, PHS, and are identical with those employed for the Radiation Surveillance Network. The air-sampling station locations are shown in figure 5.

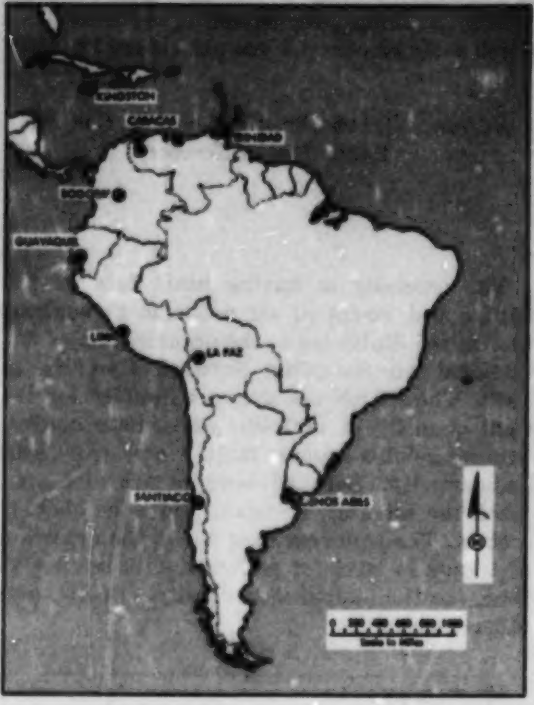


Figure 5. Pan American Air Sampling Program stations

The December 1966 air-monitoring results are given in table 5. Levels continue to decrease and all samples received from stations north of the equator were at or below the minimum reporting level (0.10 pCi/m³). Stations south of the equator were still slightly elevated. The most active sample was collected at Buenos Aires, Argentina, on December 1, 1966, and measured 0.33 pCi/m³ when counted on December 19, 1966.

No fresh fission products were identified on the 32 air samples analyzed by gamma-ray spectrometry during December 1966.

Table 5. PAHO gross beta radioactivity in surface air, December 1966

Station location	Number of samples	Gross beta radioactivity (pCi/m³)		
		Maximum	Minimum	Average [a]
Argentina: Buenos Aires	13	0.33	<0.10	0.21
Chile: Santiago	27	.26	< .10	< .17
Colombia: Bogota	20	< .10	< .10	< .10
Ecuador: Guayaquil	29	.26	< .10	.24
Jamaica: Kingston	11	< .10	< .10	< .10
Peru: Lima	NS			
Venezuela: Caracas	16	< .10	< .10	< .10
West Indies: Trinidad	12	< .10	< .10	< .10
Pan American summary	128	.33	< .10	< .14

[a] The monthly average is calculated by weighting the individual samples with length of sampling period. Values of <0.10 are assumed to be 0.10 for averaging purposes. If 10 percent or more samples from a station contain <0.10 pCi/m³, a less-than sign is placed before the average.

NS, no sample reported.

-36-

5. National Air Sampling Network October-December and annual summary, 1966

National Center for Air Pollution Control
Public Health Service

The necessity of having basic data on the nature and extent of air pollution throughout the United States led to the organization of the National Air Sampling Network (NASN) in 1953. The NASN analyzes air samples for the total quantity of airborne particulate matter, benzene-soluble organic matter, and gross beta radioactivity. Selected samples are also analyzed for nitrates, sulfates, and a number of metals. The resulting data aid in the detection of trends in levels of pollution with respect to time, location, population density, climate, and other factors.

NASN stations (figure 6) are manned by cooperating Federal, State, and local agencies. The current basic network consists of 110 sampling stations which operate every year in 73 large cities and 37 non-urban areas. In addition, there are stations in 130 cities which operate every other year. Thus, the NASN consists of 240 sampling stations, 175 of which are active in any given year.

Gross beta radioactivity in air

Continuous 24-hour samples of airborne particulate matter are taken at each station. The samples, representing approximately 2,000 cubic meters of air, are collected on glass-fiber filters on a biweekly random sampling schedule. They are sent for analysis to the network laboratory at the Robert A. Taft Sanitary Engineering Center in Cincinnati, Ohio. October to December 1966 gross beta radioactivity in air is given in table 6. The summary for 1966 is presented in table 7.

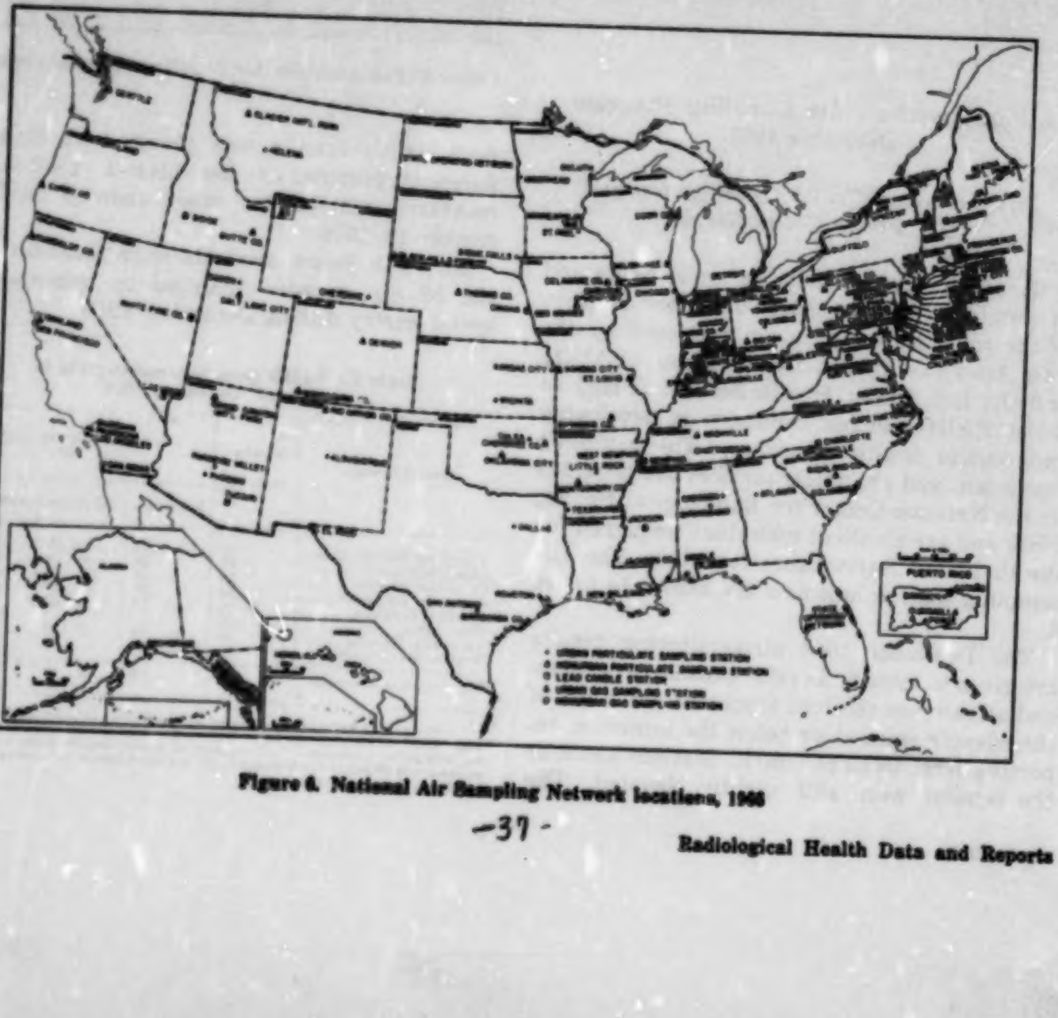

PUERTO RICO
URBAN PARTICULATE SAMPLING STATION
NONURBAN PARTICULATE SAMPLING STATION
LEAD CANDLE STATION
URBAN GAS SAMPLING STATION
NONURBAN GAS SAMPLING STATION

Figure 6. National Air Sampling Network locations, 1966

-37-

Table 6. NASN fission product gross beta radioactivity in surface air, October–December 1966

Station		Number of samples	Concentration (pCi/m³)		
			Maximum	Minimum	Average
Ala:	Birmingham	6	0.3	0.1	0.2
	Gadsden	6	2.1	< .1	.4
	Mobile	6	1.3	.1	.3
Alaska:	Anchorage	6	.2	< .1	.1
Ariz:	Grand Canyon Park *	5	.2	.1	.1
	Paradise Valley	6	.2	.1	.1
	Phoenix	6	.3	.1	.2
	Tucson	5	.2	.1	.1
Ark:	Little Rock	6	1.6	.1	.4
	Montgomery County *	6	1.2	.1	.3
	Texarkana	4	.2	.1	.1
	West Memphis	6	4.4	< .1	.8
Calif:	Burbank	6	.6	.1	.2
	Humboldt County *	6	.1	< .1	.1
	Los Angeles	6	.4	< .1	.1
	Oakland	7	.2	.1	.1
	Pasadena	6	.7	.1	.2
	San Diego	6	.2	.1	.1
	San Francisco	6	.2	< .1	.1
Colo:	Denver	5	1.5	< .1	.4
	Montezuma County *	6	.2	.1	.2
Conn:	Hartford	6	.2	< .1	.1
	New Haven	5	.3	< .1	.1
Del:	Kent County *	5	.1	< .1	.1
	Newark	6	.3	.1	.1
	Wilmington	5	.5	< .1	.2
D.C:	Washington	7	.7	.1	.2
Ga:	Atlanta	5	.3	.1	.2
Hawaii:	Honolulu	6	.5	< .1	.1
Idaho:	Boise	5	.4	.1	.2
	Butte County *	3	.6	.1	.3
Ill:	Chicago	6	3.1	< .1	.6
Ind:	East Chicago				
	Hammond				
	Indianapolis				
	N. Monroe State Forest *	5	1.7	.1	.4
	Muncie	5	.4	.1	.2
	New Albany	6	.3	.1	.2
	Parke County *	5	1.4	< .1	.4
	South Bend	6	.6	.1	.2
	Terre Haute	2	.1	.1	.1
Iowa:	Davenport	6	.1	< .1	.1
	Delaware County *	6	.2	.1	.1
	Des Moines	5	2.1	.1	.5
	Dubuque	6	.3	.1	.2
Kans:	Kansas City	5	1.5	.1	.4
	Wichita	6	.4	.1	.2
Ky:	Ashland	6	2.9	< .1	.6
	Covington	6	3.5	< .1	.7
	Louisville	6	.3	< .1	.1
La:	New Orleans	6	1.4	.1	.3
Maine:	Acadia National Park *	5	.1	< .1	.1
	Portland	4	.5	< .1	.2
Md:	Baltimore	6	.4	.1	.2
	Calvert County *	6	.4	.1	.2
Mich:	Detroit	6	3.4	.1	.7
Minn:	Duluth	6	.3	.1	.2
	Minneapolis	6	.3	< .1	.1
	Moorhead	6	.2	< .1	.1
	St. Paul	6	.2	< .1	.1
Miss:	Jackson	6	1.9	< .1	.4
	Jackson County *	6	1.5	.1	.4
Mo:	Kansas City	5	3.9	.1	.9
	St. Louis	6	5.1	.1	.9
	Shannon County *	6	3.0	< .1	.6
Mont:	Glacier National Park *	5	.2	< .1	.1
	Helena	6	.2	< .1	.1
Nebr:	Omaha	6	.2	.1	.1
	Thomas County *	6	.5	.1	.2
Nev:	Las Vegas	6	0.5	0.1	0.2
	White Pine County *	5	.2	< .1	.1
N.H:	Concord	6	.3	< .1	.2
	Coos County *	6	.5	< .1	.2
N.J:	Marlton	6	.3	.1	.1
	Camden	5	.2	< .1	.1
	Glassboro	6	.3	< .1	.1
	Jersey City	6	.6	< .1	.2
	Newark	5	.1	.1	.1
	Perth Amboy	6	.2	.1	.1
	Trenton	6	.2	.1	.1
N. Mex:	Albuquerque	5	.2	< .1	.1
	Rio Arriba County *	6	.1	.1	.1
N.Y:	Cape Vincent *	6	.6	< .1	.2
	New York	5	4.1	.1	.9
N.C:	Charlotte	6	.9	.1	.3
	Cape Hatteras *	6	.3	.1	.2
Ohio:	Akron	6	1.9	.1	.4
	Cincinnati	6	3.9	< .1	.7
	Cleveland	6	.3	< .1	.1
	Columbus	5	2.6	< .1	.8
	Dayton	6	3.2	< .1	.6
	Toledo	6	3.2	.1	.7
	Youngstown	6	1.2	< .1	.3
Okla:	Cherokee County *	6	1.4	.1	.4
	Oklahoma City	6	3.5	.1	.7
	Tulsa	5	.2	.1	.1
Ore:	Curry County *	6	.2	< .1	.1
	Portland	5	10.4	< .1	2.1
Pa:	Clarion County *	6	1.0	.1	.3
	Lancaster	6	.2	.1	.1
	Philadelphia	6	.3	< .1	.1
	Pittsburgh	6	.9	< .1	.2
	Reading	6	.3	.1	.2
	Warminster	6	.6	< .1	.2
	West Chester	4	.1	< .1	.1
P.R:	Bayamón	6	.2	< .1	.1
	Guayanilla	5	.1	< .1	.1
	Ponce	6	.1	< .1	.0
	San Juan	6	.1	< .1	.1
R.I:	Providence	5	.7	.1	.3
	Washington County *	6	.3	< .1	.1
S.C:	Columbia	4	.2	.1	.1
	Greenville	6	1.3	.1	.4
	Richland County *	6	.2	< .1	.1
S. Dak:	Black Hills Forest *	6	.2	.1	.1
	Sioux Falls	6	.2	.1	.1
Tenn:	Chattanooga	5	.3	.1	.2
	Memphis	6	4.8	.1	.9
	Nashville	5	.4	< .1	.2
Tex:	Dallas	5	1.7	.1	.4
	Houston	7	1.0	.1	.2
	Matagorda County *	6	.6	.1	.2
	Pasadena	6	.8	< .1	.2
	San Antonio	6	1.7	.1	.4
Utah:	Ogden	5	.3	< .1	.1
	Salt Lake City	5	.2	.1	.1
Vt:	Burlington	5	.3	< .1	.1
	Orange County *	6	.3	< .1	.1
Va:	Danville	6	.3	< .1	.1
	Norfolk	6	.2	< .1	.1
	Shenandoah Nat'l Park *	5	.2	< .1	.1
Wash:	Seattle	6	.2	< .1	.1
W. Va:	Charleston	5	.8	.1	.2
Wis:	Door County *	4	.3	.1	.1
	Milwaukee	6	3.5	.1	.7
Wyo:	Casper	4	.2	.1	.2
	Cheyenne	6	1.1	.1	.3
	Yellowstone Park *	6	.4	.1	.2

* Nonurban station

REFERENCES

(1) PUBLIC HEALTH SERVICE RADIATION SURVEILLANCE NETWORK. Monthly tabulation of findings. National Center for Radiological Health, Rockville, Md. 20852.

(2) BIRD, P. M., A. H. BOOTH, and P. G. MAR. Annual report of 1959 on the Radioactive Fallout Study Program, CNHW–RP–3. Department of National Health and Welfare, Ottawa, Canada (May 1960).

-38-

Table 7. NASN fission product gross beta radioactivity in surface air, annual summary 1966

Station		Number of samples	Concentration (pCi/m³)		
			Maximum	Minimum	Average
Ala:	Birmingham	26	0.7	0.1	0.2
	Gadsden	26	2.1	< .1	.3
	Mobile	26	1.3	< .0	.2
Alaska:	Anchorage	21	.3	< .1	.1
Ariz:	Grand Canyon Park *	25	6.7	< .1	.5
	Paradise Valley	26	10.8	.1	.6
	Phoenix	24	7.4	.1	.6
	Tucson	25	4.7	< .1	.4
Ark:	Little Rock	26	1.6	.1	.3
	Montgomery County *	25	1.2	.1	.2
	Texarkana	22	.5	.1	.2
	West Memphis	26	4.4	< .1	.4
Calif:	Burbank	26	1.4	.1	.2
	Humboldt County *	24	.3	< .1	.1
	Los Angeles	26	4.6	< .1	.3
	Oakland	25	.4	.1	.2
	Pasadena	25	1.9	.1	.2
	San Diego	24	2.2	< .1	.2
	San Francisco	26	.4	< .1	.1
Colo:	Denver	25	1.5	< .1	.3
	Montezuma County *	26	5.3	.1	.5
Conn:	Hartford	26	.5	< .1	.2
	New Haven	25	.4	< .0	.2
Del:	Kent County *	25	.6	< .1	.2
	Newark	25	.5	.1	.2
	Wilmington	24	1.8	< .1	.2
D.C:	Washington	25	.7	< .1	.2
Ga:	Atlanta	23	1.0	< .1	.2
Hawaii:	Honolulu	26	1.8	< .1	.2
Idaho:	Boise	25	.6	.1	.2
	Butte County *	23	.8	.1	.2
Ill:	Chicago	26	3.1	< .1	.3
Ind:	East Chicago	26	3.3	.1	.3
	Hammond	24	.5	< .1	.2
	Indianapolis	25	2.8	.1	.3
	N. Monroe State Forest *	22	1.7	< .1	.3
	Muncie	24	.5	.1	.2
	New Albany	24	.8	< .1	.2
	Parke County *	25	1.4	< .1	.2
	South Bend	24	.6	.1	.2
	Terre Haute	20	.7	.1	.2
Iowa:	Davenport	25	.8	< .1	.2
	Delaware County *	23	.4	< .1	.1
	Des Moines	25	2.1	.1	.2
	Dubuque	26	.4	.1	.2
Kans:	Kansas City	23	1.5	.1	.2
	Wichita	25	.6	.1	.2
Ky:	Ashland	25	2.9	< .1	.3
	Covington	26	3.5	< .1	.3
	Louisville	25	.7	< .1	.2
La:	New Orleans	26	1.4	.1	.3
Maine:	Acadia National Park *	24	.3	< .1	.1
	Portland	19	.5	< .1	.1
Md:	Baltimore	26	.5	< .1	.2
	Calvert County *	25	.4	< .1	.2
Mich:	Detroit	26	3.4	< .1	.3
Minn:	Duluth	26	.5	.1	.2
	Minneapolis	26	.5	< .1	.2
	Moorhead	26	.4	< .1	.1
	St. Paul	25	.4	< .1	.2
Miss:	Jackson	26	1.9	< .1	.3
	Jackson County *	26	1.5	< .1	.2
Mo:	Kansas City	24	3.9	.1	.3
	St. Louis	24	5.1	.1	.4
	Shannon County *	24	3.0	< .1	.3
Mont:	Glacier National Park *	24	.9	< .1	.2
	Helena	26	1.1	< .1	.2
Nebr:	Omaha	25	.4	.1	.2
	Thomas County *	26	.8	.1	.2
Nev:	Las Vegas	26	5.9	0.1	0.6
	White Pine County *	23	5.6	< .1	.5
N.H:	Concord	20	.8	< .1	.2
	Coos County *	25	.5	< .1	.2
N.J:	Marlton	26	.5	< .1	.3
	Camden	25	.4	< .1	.3
	Glassboro	26	.5	< .1	.3
	Jersey City	23	.6	< .1	.2
	Newark	20	.4	< .1	.1
	Perth Amboy	24	.5	.1	.2
	Trenton	22	.3	< .1	.1
N. Mex:	Albuquerque	25	3.5	< .1	.4
	Rio Arriba County *	24	1.9	.1	.3
N.Y:	Cape Vincent *	25	.5	< .1	.2
	New York	24	4.1	< .1	.3
N.C:	Charlotte	26	.9	< .1	.2
	Cape Hatteras *	23	.6	< .1	.1
Ohio:	Akron	25	1.9	< .1	.3
	Cincinnati	25	3.9	< .1	.3
	Cleveland	26	.7	< .1	.2
	Columbus	25	3.6	< .1	.4
	Dayton	26	3.2	< .1	.3
	Toledo	26	3.2	< .1	.3
	Youngstown	26	1.2	< .1	.2
Okla:	Cherokee County *	26	1.4	.1	.2
	Oklahoma City	26	3.5	.1	.4
	Tulsa	25	.9	.1	.3
Ore:	Curry County *	24	.2	< .1	.1
	Portland	22	10.4	< .1	.6
Pa:	Clarion County *	24	1.0	.1	.2
	Lancaster	26	.9	.1	.2
	Philadelphia	24	.6	< .1	.2
	Pittsburgh	26	.9	< .1	.2
	Reading	25	.7	< .1	.2
	Warminster	24	.6	< .1	.2
	West Chester	19	.7	< .1	.2
P.R:	Bayamon	26	.7	< .1	.1
	Guayanilla	25	1.1	< .1	.2
	Ponce	26	.5	< .1	.1
	San Juan	25	1.6	< .1	.2
R.I:	Providence	24	.7	.1	.2
	Washington County *	23	.4	< .1	.2
S.C:	Columbia	23	.8	.1	.2
	Greenville	26	1.3	.1	.2
	Richland County *	26	.4	< .1	.2
S. Dak:	Black Hills Forest *	25	.6	.1	.2
	Sioux Falls	26	1.8	< .1	.2
Tenn:	Chattanooga	23	.7	< .1	.2
	Memphis	26	4.8	.1	.4
	Nashville	24	.5	< .1	.2
Tex:	Dallas	24	1.7	.1	.3
	Houston	26	1.0	< .1	.2
	Matagorda County *	23	1.2	< .1	.2
	Pasadena	10	.8	< .1	.2
	San Antonio	25	1.7	< .1	.2
Utah:	Ogden	24	.9	< .1	.2
	Salt Lake City	24	1.9	.1	.3
Vt:	Burlington	25	.9	< .1	.2
	Orange County *	[illegible]	.6	< .1	.2
Va:	Danville	24	1.4	< .1	.3
	Norfolk	26	.4	< .1	.1
	Shenandoah Nat'l Park *	25	.4	< .1	.1
Wash:	Seattle	26	.3	< .1	.1
W. Va:	Charleston	22	.8	.1	.2
Wis:	Door County *	19	.2	< .1	.1
	Milwaukee	25	3.5	< .1	.3
Wyo:	Casper	4	.2	.1	.2
	Cheyenne	26	1.1	.1	.3
	Yellowstone Park *	25	1.7	.1	.3

* Nonurban station

(*3*) BIRD, P. M., A. H. BOOTH, and P. G. MAR. Annual report for 1960 on the Radioactive Fallout Study Program, CNHW-RP-4. Department of National Health and Welfare, Ottawa, Canada (December 1961).

(*4*) MAR, P. G. Annual report for 1961 on the Radioactive Fallout Study Program, CNHW-RP-5. Department of National Health and Welfare, Ottawa, Canada (December 1962).

(*5*) BEALE, J., and J. GORDON. The operation of the Radiation Protection Division Air Monitoring Program, RPD–11. Department of National Health and Welfare, Ottawa, Canada (July 1962).

(*6*) BOOTH, A. H. The calculation of permissi[illegible] levels of fallout in air and water and their use in [illegible]ng the significance of 1961 levels in Canada, [illegible]–21. Department of National Health and Welfare, [illegible]awa, Canada (August 1962).

(*7*) VASQUEZ, M., and R. M. DE NULMAN. Estudios sobre la radioactividad ambiental en la República Mexicana, 1963–1965. Comisión Nacional de Energía Nuclear. Dirección General de Segurid[illegible]adiológica (en prensa 1966).

Section IV. Other Data

This section presents results from routine sampling of biological materials and other media not reported in the previous sections. Included are such data as those obtained from human bone sampling, bovine thyroid sampling, and environmental monitoring reports.

IODINE-131 IN BOVINE THYROIDS, JULY–DECEMBER 1966

National Center for Radiological Health
Public Health Service

To supplement its existing environmental surveillance systems, the National Center for Radiological Health established a Bovine Thyroid Network in October 1964 (*1*). Specimens are collected by the Meat Inspection Division, U.S. Department of Agriculture, and analyzed by gamma-ray spectrometry for iodine-131 content at the Northeastern Radiological Health Laboratory, Winchester, Mass.

The network consists of collection areas (countries shaded in figure 1) located so as to cover, as nearly as possible, areas near major nuclear reactors, spent-fuel reprocessing plants, and nuclear test sites. Details of sampling and analysis have been published earlier (*1*). For this report, the collection areas sampled during July through December 1966 were grouped on a broad geographical basis as shown in figure 1.

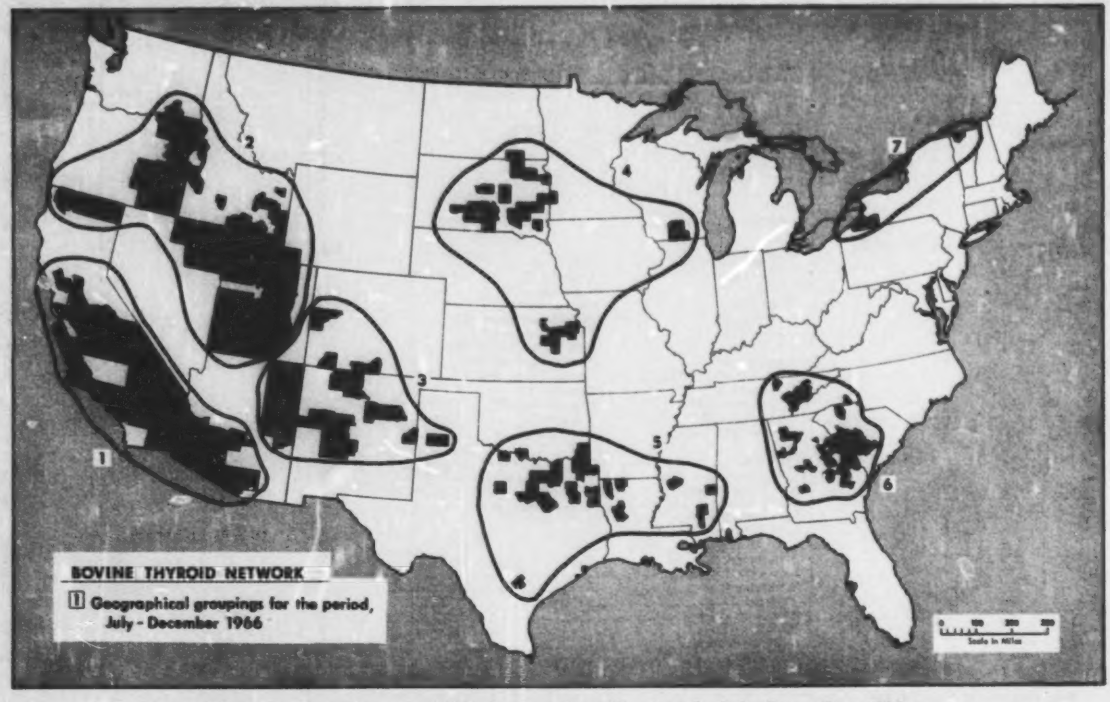

1
2
3
4
5
6
7
BOVINE THYROID NETWORK
1 Geographical groupings for the period, July - December 1966
0 100 200 300
Scale in Miles

Figure 1. Counties sampled in bovine thyroid network, July–December 1966

-40-

Table 1. Iodine-131 in bovine thyroids, July–December 1966

Geographical grouping [a]	Date of slaughter	County of origin	Number of samples	pCi iodine-131/g thyroid		
				Average or concentration	Minimum	Maximum
1 Southwestern Arizona and California	7/1	Kings	1	ND		
		San Bernardino	2	ND		
		San Luis Obispo	1	ND		
	7/5	Merced	4	ND		
		Stanislaus	2	ND		
	7/6	Los Angeles	2	ND		
		San Joaquin	2	2	ND	3
		Santa Clara	2	9	8	10
	7/7	Los Angeles	2	25	24	26
		San Bernardino	4	16	15	18
	7/8	Kings	2	21	ND	41
		Los Angeles	1	6		
		Ventura	1	2		
	7/11	Merced	2	3	ND	2
		Stanislaus	4	<1	ND	3
	7/12	Los Angeles	2	1	ND	2
		San Joaquin	2	2	ND	2
		Santa Clara	2	12	11	12
	7/13	Los Angeles	2	1	ND	2
	7/15	Los Angeles	2	4	ND	2
		Stanislaus	1	ND		
		Tulare	1	2		
	7/18	Los Angeles	2	4	ND	8
		San Joaquin	2	24	21	26
		Santa Barbara	1	ND		
		Stanislaus	2	30	27	32
	7/19	Merced	3	ND		
		San Joaquin	2	15	ND	30
	7/20	Los Angeles	1	ND		
	7/21	San Bernardino	2	1	ND	2
	7/22	Los Angeles	3	4	3	6
		Tulare	2	ND		
		Ventura	1	ND		
	7/25	Los Angeles	2	ND		
		Merced	4	8	3	13
		Stanislaus	2	5	3	7
	7/26	Los Angeles	3	ND		
		Merced	2	ND		
		Stanislaus	2	2	ND	4
	7/27	Riverside	1	ND		
	7/28	San Joaquin	2	ND		
	7/29	Los Angeles	2	ND		
	8/1	Merced	4	ND		
		San Joaquin	3	ND		
	8/2	San Joaquin	2	8	5	11
		Stanislaus	2	8	7	9
	8/3	Los Angeles	2	2	ND	3
		San Bernardino	2	ND		
	8/4	Los Angeles	1	ND		
		Riverside	1	ND		
	8/6	Tulare	2	ND		
	8/8	Monterey	2	ND		
		Sacramento	2	2	ND	4
		Stanislaus	2	ND		
	8/9	Fresno	3	ND		
		Stanislaus	4	7	ND	16
	8/10-11/7 [b]	[Arizona] [c] Maricopa (21) [c] Pinal (0) Yuma (1) [California] Fresno (11) Imperial (0) Inyo (1) Kings (9) Los Angeles (53) Madera (2) Mariposa (0) Merced (20) Monterey (22) Napa (1) Orange (2) Riverside (5) Sacramento (11) San Bernardino (9) San Joaquin (31) San Luis Obispo (1) Santa Barbara (4) Santa Clara (0) Solano (1) Stanislaus (29) Tulare (1) Ventura (0)	235	[d] ND		
	11/8	Imperial	2	ND		
		Merced	2	6	ND	12
		San Bernardino	2	ND		
		San Joaquin	2	7	4	10
	11/9	San Bernardino	2	ND		
	11/10	Los Angeles	2	ND		
	11/14	Fresno	2	18	17	20
		Monterey	2	33	25	41
		San Bernardino	2	5	ND	10
		Stanislaus	2	13	ND	16
		Tulare	2	ND		
	11/15	San Bernardino	2	ND		
		San Joaquin	2	1	ND	2
		Santa Barbara	1	39		
		Stanislaus	2	5	ND	10

See footnotes at end of table.

Table 1. Iodine-131 in bovine thyroids, July–December 1966—Continued

Geographical grouping [a]	Date of slaughter	County of origin	Number of samples	pCi iodine-131/g thyroid		
				Average or concentration	Minimum	Maximum
1 Continued	11/18	Pinal	2	ND		
		Santa Barbara	2	16	13	18
	11/21	Merced	2	28	14	40
		San Joaquin	4	143	15	268
		Stanislaus	2	84	64	104
	11/22	Mariposa	3	15	ND	30
		San Bernardino	4	ND		
		Stanislaus	2	13	13	13
	11/25	Los Angeles	2	ND		
		Maricopa	2	ND		
	11/26	Orange	2	ND		
	11/28	Madera	2	57	46	68
		Merced	2	ND		
		Stanislaus	4	38	7	97
	11/29	San Bernardino	2	ND		
		San Joaquin	2	2	ND	4
		Stanislaus	3	67	3	132
	12/1	Riverside	4	<1	ND	3
	12/2	Los Angeles	1	ND		
		Maricopa	2	ND		
		San Bernardino	1	100		
	12/5	Merced	5	72	54	105
		San Joaquin	1	34		
	12/6	San Joaquin	2	ND		
		Stanislaus	2	13	ND	25
	12/8	Los Angeles	5	ND		
		Maricopa	2	13	6	19
		San Bernardino	2	ND		
	12/13	Merced	3	3	ND	10
		San Joaquin	3	41	4	78
	12/14	Orange	2	ND		
	12/15	Maricopa	1	ND		
		San Bernardino	3	ND		
	12/16	Maricopa	3	ND		
		San Bernardino	3	ND		
	12/20	Los Angeles	5	<1	ND	3
		San Bernardino	5	ND		
	12/21	Sacramento	2	24	ND	47
	12/22	Monterey	3	12	ND	23
	12/23	Maricopa	2	ND		
	12/27	Merced	2	ND		
		San Joaquin	1	11		
	12/28	Riverside	5	ND		
		San Bernardino	2	ND		
	12/30	Maricopa	2	ND		
		San Bernardino	2	ND		
2 Northern California, Idaho, Nevada, Oregon, Utah, Washington, and Wyoming	7/6	Sanpete	1	87		
		Sevier	1	22		
		Utah	3	27	3	54
		Walla Walla	6	9	2	33
	7/7	Ada	1	ND		
		Canyon	1	ND		
		(Idaho) [f]	3	5	ND	14
	7/12	Sevier	2	24	3	44
		Utah	3	17	9	29
	7/13	Cache	1	54		
		Caribou	1	11		
		(Utah) [f]	2	15	6	24
	7/14	Bear Lake	1	66		
		Canyon	1	ND		
		Payette	1	9		
	7/15	Salt Lake	5	31	19	48
	7/18	Siskiyou	2	23	15	31
	7/21	Beaver	1	22		
		Iron	1	86		
		Millard	2	21	19	22
		Salt Lake	1	16		
		Summit	1	4		
		Utah	1	17		
		Washington	[illegible]	15	6	24
	7/27	Cache	[illegible]	7		
		Morgan	[illegible]	20	20	20
		Uinta	2	15	11	19
	7/28	Emery	1	15		
		Sevier	4	10	5	14
		Beaver	2	7	ND	13
	8/4	Garfield	1	4		
		Sanpete	1	7		
		Tooele	1	4		
	8/8	Ada	1	5		
		Gem	1	ND		
		(Idaho) [f]	4	1	ND	5
	8/9	Cache	1	3		
		Weber	6	5	ND	9

See footnotes at end of table.

-42-

Table 1. Iodine-131 in bovine thyroids, July–December 1966—Continued

Geographical grouping [a]	Date of slaughter	County of origin	Number of samples	pCi iodine-131/g thyroid		
				Average or concentration	Minimum	Maximum
2 Continued	8/10–11/9 [b]	[California] [c] Modoc (2) [e] Siskiyou (8) [Idaho] Ada (9) Adams (0) Bear Lake (0) Bingham (0) Caribou (0) Cassia (6) Canyon (40) Gem (0) Gooding (1) Madison (5) Oneida (4) Payette (0) Unknown (7) [Nevada] Elko (1) [Oregon] Baker (6) Harney (0) Malheur (10) Umatilla (1) Union (3) Wallowa (1) [Utah] Beaver (2) Box Elder (3) Cache (1) Davis (1) Duchesne (1) Emery (5) Garfield (0) Iron (0) Kane (2) Millard (5) Morgan (3) Rich (1) Salt Lake (5) Sanpete (1) Sevier (7) Summit (2) Tooele (0) Unknown (5) Utah (12) Wasatch (2) Washington (0) Wayne (1) Weber (32) [Washington] Walla Walla (49) [Wyoming] Uinta (0)	242	[d] ND		
	11/17	Baker	2	51	9	92
		Canyon	2	2	ND	3
		Harney	1	144		
		Madison	5	<1	ND	2
	11/18	Modoc	2	129	13	244
	11/23	Canyon	10	218	138	261
	11/25	Bingham	5	<1	ND	2
	11/28	Millard	1	ND		
		Salt Lake	4	152	4	279
	11/30	Millard	5	<1	ND	2
	12/1	Canyon	2	37	36	37
		Malheur	4	24	2	48
		(Oregon) [f]	4	58	26	105
	12/8	Sanpete	5	ND		
	12/14	Cassia	5	ND		
	12/16	Harney	10	38	ND	77
		Walla Walla	5	9	ND	25
	12/21	Canyon	7	ND		
	12/27	Siskiyou	2	ND		
	12/30	Adams	4	13	3	21
3 Northeastern Arizona, Colorado, New Mexico, & western Texas	7/1	Swisher	1	40		
	7/5	Bernalillo	4	14	4	22
	7/6	Curry	4	105	50	163
	7/11	Bernalillo	4	44	ND	98
	7/12	Curry	4	24	19	31
	7/18	Conejos	8	25	11	56
	7/25	Valencia	4	10	7	12
	7/26	Curry	4	8	2	10
	8/1	Conejos	4	3	ND	7
	8/2	Valencia	4	10	2	13
	8/8	Valencia	4	4	4	5
	8/9	Curry	4	3	ND	4
	8/15–11/9 [b]	[Arizona] [c] Apache (2) [e] Navajo (2) [Colorado] Conejos (0) Costilla (12) LaPlata (4) Mesa (1) [New Mexico] Bernalillo (12) Curry (16) Rio Arriba (0) San Miguel (4) Socorro (4) Valencia (28) [Texas] Castro (1) Swisher (0)	86	[d] ND		
	11/14	Valencia	4	41	7	60
	11/15	Conejos	4	19	ND	33
	11/21	Conejos	4	32	18	56
	11/22	Valencia	4	90	71	106
	11/28	Curry	4	51	14	89
	11/29	Bernalillo	3	27	21	34
		Rio Arriba	1	51		
	12/5	Valencia	4	22	4	39
	12/6	Valencia	4	30	9	48
	12/12	Valencia	4	16	6	29

See footnotes at end of table.

-43-

Table 1. Iodine-131 in bovine thyroids, July–December 1966—Continued

Geographical grouping [a]	Date of slaughter	County of origin	Number of samples	pCi iodine-131/g thyroid		
				Average or concentration	Minimum	Maximum
3 Continued						
	12/13	Bernalillo	1	ND		
		San Miguel	3	14	9	23
	12/19	Bernalillo	1	ND		
		Curry	2	4	2	6
	12/20	LaPlata	4	11	ND	18
	12/27	Valencia	4	5	ND	9
	12/28	Bernalillo	1	ND		
		LaPlata	5	3	ND	6
4 Kansas, Iowa, Minnesota, N. Dakota, S. Dakota, and Wisconsin	7/1	Brown	10	74	27	203
		Douglas (Kans)	1	29		
	7/6	Green	2	19	5	33
		Lyon (Kans)	2	23	21	25
	7/7	Dane	5	7	ND	19
	7/8	Sanborn	6	57	29	103
	7/11	Aurora	7	142	103	190
		Dane	2	6	4	7
	7/19	Brookings	1	7		
		Green	2	4	3	5
	7/20	Rock	6	13	ND	26
	7/22	Day	4	<1	ND	3
		Hanson	1	13		
	7/25	Lyon (Iowa)	4	29	10	54
	7/26	Lyon (Iowa)	3	27	16	35
	7/27	Dane	5	3	ND	9
		Lyon (Iowa)	1	18		
		Rock	2	ND		
	8/5	Aurora	6	17	10	23
		Green	2	5	3	6
	8/9	Aurora	10	11	5	17
	8/10	Dane	5	1	ND	4
	8/12–11/3 [b]	[Kansas] [c] Douglas (0) [e] Jefferson (0) Leavenworth (0) Lyon (0) Morris (0) Riley (0) Shawnee (5) Wabaunsee (0) [Iowa] Lyon (0) [Minnesota] Lincoln (0) [North Dakota] Dickey (8) [South Dakota] Aurora (13) Brookings (0) Brown (15) Davidson (10) Day (0) Douglas (0) Grant (0) Hand (0) Hanson (0) Jackson (0) Jones (0) Lake (2) Lyman (10) Mellette (0) Miner (4) Sanborn (0) Sully (0) Tripp (10) Turner (4) [Wisconsin] Dane (25) Green (8) Rock (40)	164	[d] ND		
	11/10	Rock	7	6	ND	16
	11/14	Aurora	2	21	ND	42
		Dane	2	7	ND	14
		Jackson	1	ND		
		Lyman	1	ND		
		Mellette	2	15	ND	29
		(South Dakota) [f]	5	2	ND	10
	11/18	Jones	9	ND		
	11/22	Green	4	9	ND	26
		Rock	3	7	ND	17
	11/29	Rock	9	1	ND	6
	11/30	Lyman	5	ND		
		(South Dakota) [f]	3	ND		
	12/1	Jefferson	1	51		
	12/2	Green	2	19	14	23
	12/6	Lincoln	1	ND		
		Mellette	2	65	51	78
	12/7	Lincoln	7	4	ND	10
	12/8	Riley	1	17		
	12/9	Dane	3	ND		
		Shawnee	1	7		
	12/12	Douglas (Kans)	1	32		
	12/14	Rock	5	4	ND	9
	12/15	Douglas (Kans)	1	34		
		Hand	9	ND		
		Lyon (Kans)	2	ND		
	12/16	Morris	1	ND		
	12/20	Leavenworth	1	ND		
	12/21	Mellette	10	6	ND	13
		Rock	4	ND		
	12/27	Dane	2	ND		
	12/29	Douglas (S. Dak)	5	2	ND	5
		Sully	4	3	ND	4
	12/30	Wabaunsee	2	24	18	30

See footnotes at end of table.

Table 1. Iodine-131 in bovine thyroids, July–December 1966—Continued

Geographical grouping [a]	Date of slaughter	County of origin	Number of samples	pCi iodine-131/g thyroid: Average or concentration	Minimum	Maximum
5 Mississippi, Louisiana, Oklahoma, and Eastern Texas	7/1	Denton	1	76		
		Tarrant	1	68		
	7/5	Marion	5	29	10	49
	7/20	Hunt	1	11		
	7/27	Hunt	1	12		
	7/28	McCurtain	2	7	5	9
	8/2	Lauderdale	3	3	ND	5
	8/6	Forrest	5	2	ND	6
	8/16–11/1 [b]	[Mississippi] [c] Forest (15) [c] Jones (10) Lauderdale (9) Yasoo (5) [Louisiana] Bossier (2) Claiborne (3) Natchitoches (1) [Oklahoma] Jefferson (1) McCurtain (1) [Texas] Bowie (1) Collin (1) Dentin (0) Ellis (3) Fanin (1) Harrison (2) Hood (1) Hunt (2) Johnson (1) Karnes (2) Navarro (0) Panola (1) Red River (3) Smith (3) Stephens (0) Tarrant (0) Titus (3) Unknown (1) Wichita (0) Wood (3)	78	[d] ND		
	11/9	Navarro	2	73	5	141
	11/11	Tarrant	1	114		
	11/17	Titus	4	86	13	166
	11/18	Wichita	1	204		
	11/23	Stephens	2	83	64	101
	12/9	Ellis	2	48	34	62
	12/21	Tarrant	2	8	5	10
6 Georgia, North Carolina, South Carolina, and Tennessee	7/6	Blount	2	47	36	58
		Candler	3	8	2	19
		Carroll	1	27		
		Knox	2	29	15	43
		Loudon	1	86		
	7/7	Clarke	3	50	39	78
	7/8	Clarke	1	24		
		Washington	1	44		
	7/11	Spartanburg	1	9		
		Washington	1	28		
	7/12	Grainger	1	34		
		Knox	3	41	26	53
		Sevier	2	44	39	48
	7/13	Bibb	2	17	9	24
		Columbia	1	31		
		Laurens	3	24	22	25
	7/18	Sumter	1	ND		
	7/19	Sumter	2	ND		
	7/20	Bamberg	6	13	6	21
		Blount	2	16	14	17
		Knox	2	9	6	11
		Laurens	2	10	7	13
		Sevier	1	21		
	7/25	Bartow	5	7	3	10
	7/26	Forsyth	1	12		
		Orangeburg	4	7	4	12
	8/1	Burke	1	ND		
		Screven	1	ND		
	8/2	Blount	1	ND		
		Fentress	1	2		
		Grainger	2	7	6	7
		Greenwood	1	2		
		Knox	1	2		
		Lincoln	1	ND		
		McCormick	1	6		
		Screven	1	ND		
	8/3	Greene	2	8	7	9
		Saluda	1	ND		
		Warren	3	4	2	6
	8/9	Blount	1	3		
		Grainger	1	ND		
		Knox	1	ND		
		Sevier				
	8/10–8/16 [b]	[Georgia] [c] Laurens (5) [c] McDuffie (4) Monroe (5) [South Carolina] Bamberg (1) [Tennessee] Blount (5) Grainger (1)	21	[d] ND		

See footnotes at end of table.

Table 1. Iodine-131 in bovine thyroids, July–December 1966—Continued

Geographical grouping [a]	Date of slaughter	County of origin	Number of samples	pCi iodine-131/g thyroid		
				Average or concentration	Minimum	Maximum
8 Continued						
	8/23	Forsyth	1	139		
		Monroe (Ga)	1	ND		
		Orangeburg	2	25	16	33
	8/24	Blount	2	3	2	3
		Grainger	1	4		
		Jefferson	1	3		
		Knox	2	3	2	3
	8/25–11/1 [b]	[Georgia] [c] Bartow (0) [e] Bibb (9) Burke (3) Candler (3) Carroll (0) Cherokee (2) Clarke (0) Cloumbia (0) Emanual (1) Forsyth (0) Fulton (1) Gorden (1) Greene (6) Hancock (1) Jenkins (2) Laurens (0) Lincoln (0) McDuffie (1) Monroe (1) Richmond (0) Screven (7) Sumter (0) Tattnell (2) Toombs (0) Upson (4) Warren (7) Wilkes (8) [North Carolina] Cleveland (2) [South Carolina] Aiken (4) Bamberg (3) Barnwell (2) Edgefield (2) Greenwood (5) Lexington (5) McCormick (2) Orangeburg (0) Saluda (11) Spartanburg (6) [Tennessee] Blount (23) Fentress (0) Grainger (1) Jefferson (0) Knox (12) Loudon (1) Monroe (4) Sevier (6) Roane (1) Unknown (1)	151	[d] ND		
	11/8	Blount	1	53		
		Grainger	1	ND		
		Knox	2	89	68	109
		Laurens	3	ND		
		Sevier	2	60	15	104
		Tattnell	1	ND		
		Upson	4	1	ND	2
		Washington	2	1	ND	2
	11/14	Blount	1	52		
	11/15	Blount	2	43	15	71
		Cleveland	2	90	66	113
		Greenwood	1	123		
		McCormick	1	125		
		Roane	1	44		
		Toombs	3	34	10	79
		Warren	2	107	74	139
		Wilkes	1	117		
	11/21	Cleveland	1	8		
		Columbia	1	4		
		Greene	2	8	4	11
		Greenwood	1	8		
		Saluda	3	12	4	21
		Screven	1	8		
		Warren	1	14		
	11/22	Blount	1	78		
		Jefferson	1	158		
		Knox	2	67	37	97
		Loudon	2	82	66	97
	11/28	Blount	2	87	68	106
		Monroe (Tenn)	1	149		
		Screven	2	9	7	10
		Sevier	2	30	2	57
	11/29	Columbia	1	11		
		Greenwood	1	35		
		Lexington	1	23		
		Richmond	1	18		
		Saluda	2	6	5	6
		Wilkes	2	26	13	38
	12/5	Spartanburg	10	6	2	11
	12/6	Blount	6	89	5	124
	12/13	Aiken	1	5		
		Cleveland	2	7	5	9
		Columbia	1	2		
		Greene	1	4		
		Greenwood	1	7		
		Saluda	2	3	2	4
		Screven	1	6		
	12/13	Warren	1	3		
	12/14	Blount	5	30	7	62
		Knox	1	55		

See footnotes at end of table.

-46-

Table 1. Iodine-131 in bovine thyroids, July-December 1966—Continued

Geographical grouping [a]	Date of slaughter	County of origin	Number of samples	pCi iodine-131/g thyroid		
				Average or concentration	Minimum	Maximum
6 Continued						
	12/20	Aiken	1	ND		
		Barnwell	1	ND		
		Blount	4	15	11	18
		Burke	2	ND		
	12/20	Columbia	1	ND		
		Greene	2	ND		
		Greenwood	1	ND		
		Saluda	1	ND		
		Sevier	2	17	9	25
		Wilkes	1	ND		
	12/28	Barnwell	1	ND		
		Blount	2	6	2	9
		Cleveland	2	ND		
		Hancock	1	ND		
		Jefferson	1	10		
		McCormick	1	ND		
		Monroe (Tenn)	2	ND		
		Saluda	3	ND		
		Wilkes	2	ND		
7 New York and Vermont	7/6	Chautauqua	10	12	2	31
	7/7	Cattaraugus	1	41		
	7/11	Franklin	9	9	ND	17
	7/12	Franklin	10	ND		
	7/13	Chautauque	10	7	2	13
	7/15	Cattaraugus	7	9	5	13
	7/20	Chatauqua	10	2	ND	7
	7/21	Cattaraugus	4	5	2	7
	7/27	Chautauqua	10	2	ND	4
		Franklin	10	ND		
	7/28	Cattaraugus	4	2	ND	4
	8/2	Franklin	6	3	ND	6
	8/4	Cattaraugus	1	ND		
		Chautauqua	10	2	ND	6
	8/10	Chautauqua	10	2	ND	6
	8/11–11/14 [b]	[New York] [c] Cattaraugus (23) [e] Chautauqua (126) [Vermont] Franklin (84)	233	[d] ND		
	11/16	Chautauqua	10	29	ND	191
	11/23	Chautauqua	10	10	ND	58
	11/28	Franklin	10	ND		
	11/30	Chautauqua	10	7	ND	53
	12/7	Chautauqua	10	5	ND	23
	12/14	Chautauqua	9	ND		
		Franklin	10	ND		
	12/21	Chautauqua	11	1	ND	15
	12/28	Franklin	10	ND		

[a] Geographical areas (designated in figure 1) encompass counties that were sampled in the States indicated.

[b] Samples were not collected on all dates during this period, but the interval includes several sampling dates.

[c] Brackets give State and are followed by counties sampled during the period indicated or on some other date during July-December 1966.

[d] The results for this period were for the most part not detectable. Some positive results were obtained, but represented barely detectable amounts of iodine-131 in the bovine thyroid. In general, these positive results were 2–5 pCi/g thyroid and randomly scattered over the time period and counties indicated.

[e] Numbers in parentheses represent the number of samples collected from each county during the interval indicated. These may have been collected over several dates during the period or on only one date. (0) indicates that the county was not sampled during the interval given but was sampled on another date during July-December 1966. (Unknown) refers to a sample collected in an unspecified county.

[f] The exact county is unknown.

ND, not detectable; the two standard deviation counting error was greater than or equal to the concentration observed. For the counting system utilized and these very low concentrations the two standard deviation counting errors were generally 1–3 pCi/g thyroid.

The results for July through December 1966 appear in table 1 and are listed chronologically within the geographical groupings delineated in figure 1. The influx of fallout iodine-131 following the mainland China atmospheric nuclear detonation of May 9, 1966, which was observed during the early and middle part of June 1966 (*2*), declined to barely detectable levels in early August 1966. The influx of fallout iodine-131 following the subsequent Chinese test of October 27, 1966, EST., was observed through November and December 1966, with peak values for individual specimens in the various geographical groupings ranging from 80 to 280 pCi/g thyroid during the latter part of November and early part of December 1966. Over the period August 23-24, iodine-131 was detected in isolated samples collected from one county in Georgia and one county in South Carolina.

REFERENCES

(*1*) BARATTA, E. J., E. R. WILLIAMS, and G. MURRAY. Iodine-131 in bovine thyroid, October-December 1964. Radiol Health Data 6:569–574 (October 1965).

(*2*) PUBLIC HEALTH SERVICE, NATIONAL CENTER FOR RADIOLOGICAL HEALTH. Iodine-131 in bovine thyroids, January–June 1966. Radiol Health Data Rep 8:51–55 (January 1967).

ENVIRONMENTAL LEVELS OF RADIOACTIVITY AT ATOMIC ENERGY COMMISSION INSTALLATIONS

The U.S. Atomic Energy Commission (AEC) receives from its contractors semiannual reports on the environmental levels of radioactivity in the vicinity of major AEC installations. The reports include data from routine monitoring programs where operations are of such a nature that plant environmental surveys are required.

Releases of radioactive materials from AEC installations are governed by radiation standards set forth by AEC's Division of Operational Safety in directives published in the "AEC Manual."[1]

Summaries of the environmental radioactivity data follow for the Bettis Atomic Power Laboratory, Feed Materials Production Center, Knolls Atomic Power Laboratory, and the S1C Prototype Reactor Facility.

---

[1] Title 10, Code of Federal Regulations, Part 20 "Standards for Protection Against Radiation," Appendix B, Note 3.C, contains the applicable AEC standard.

---

1. Bettis Atomic Power Laboratory
January-June 1966[2]

Westinghouse Electric Corporation
Pittsburgh, Pennsylvania

The Bettis Atomic Power Laboratory (BAPL), operated for the Atomic Energy Commission by the Westinghouse Electric Corporation, was established in 1949 to conduct research and development operations related to naval atomic propulsion systems and to the central station power reactor at Shippingport, Pennsylvania. Routine environmental monitoring data from the sampling locations shown in figure 1 show no significant contribution from laboratory operations to environmental radioactivity levels.

Liquid radioactive waste

Liquid effluent discharged from the laboratory is sampled continuously. Composite samples are analyzed weekly for gross alpha and gross beta-gamma radioactivity, and quarterly for strontium-90 activity.

The average concentration of gross beta radioactivity in the main laboratory liquid effluent during the first 6 months of 1966 was 140 pCi/liter. This was lower than the average concentration of 650 pCi/liter observed in the second half of 1965. The maximum and minimum gross beta radioactivity detected in the weekly samples amounted to concentrations of 590 pCi/liter and 20 pCi/liter, respectively.

The average concentration of gross alpha-particle activity in the main laboratory effluent was 7.4 pCi/liter, a reduction from the 11 pCi/liter average for the previous 6-month period. The maximum gross alpha-particle activity detected in weekly samples during this period was 16 pCi/liter while the minimum was 0.79 pCi/liter.

The average concentration of strontium-90 in liquid waste was 3.9 pCi/liter, versus 20 pCi/liter for the second 6 months of 1965.

Average radioactivity concentrations in liquid waste effluent from the critical facility operations during the first half of 1966 were: alpha radioactivity, <68 pCi/liter; beta-gamma radioactivity, 1.3×10^3 pCi/liter. Comparable values for the last half of 1965 were <68 pCi/liter for alpha radioactivity, and 1.5×10^3 pCi/liter for beta-gamma radioactivity.

Background monitoring stations

Beta-gamma background radiation levels were continuously monitored and recorded at 34 film badge monitoring stations located at 100-yard intervals along the boundary of the laboratory property which lies within the controlled confines of the Bettis Atomic Power Laboratory site.

---

[2] Summarized from "Environmental Radioactivity at the Bettis Atomic Power Laboratory for the First 6 Months of 1966" (PNR-DEV-138).

-48-

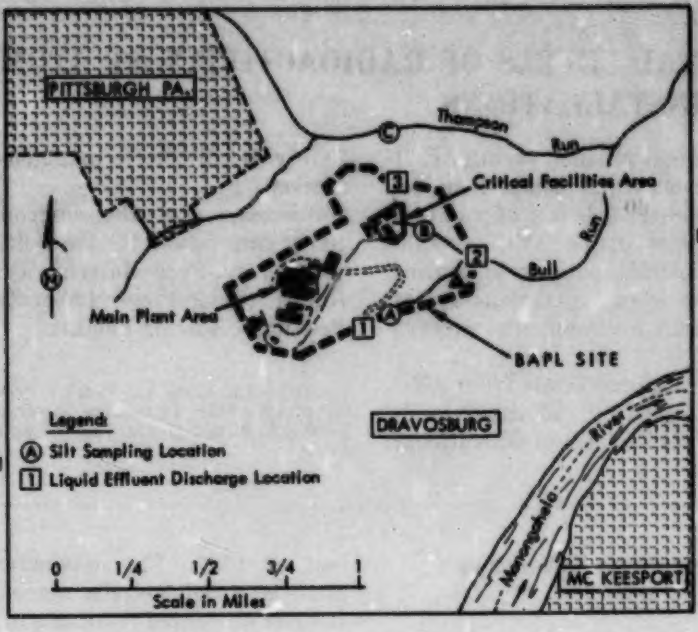

PITTSBURGH PA.
Thompson Run
Critical Facilities Area
Bull Run
Main Plant Area
BAPL SITE
DRAVOSBURG
Legend:
Ⓐ Silt Sampling Location
1 Liquid Effluent Discharge Location
A
B
C
1
2
3
N
0
1/4
1/2
3/4
1
Scale in Miles
Monongahela River
MC KEESPORT

Figure 1. Bettis Atomic Power Laboratory sampling stations

The average beta-gamma background radiation level during the first half of 1966 was 0.067 mR/hr for the main laboratory area, and 0.028 mR/hr for the critical facility area. The respective average exposure values for the period from November 11 (when film badge monitoring began) through December 31, 1965, were 0.034 mR/hr and 0.020 mR/hr. Table 1 summarizes results obtained during the first half of 1966 from the background-monitoring stations.

Table 1. Beta-gamma background radiation monitoring, Bettis, January–June 1966

Location	January–June 1966 average exposure rate (mR/hr)
Main laboratory area	
Maximum of 20 locations	0.315
Minimum of 20 locations	0.005
20 locations	0.067
Critical facility area	
Maximum of 14 locations	0.072
Minimum of 14 locations	0.006
14 locations	0.028
BAPL	
34 locations	0.051

Stream silt

Stream silt samples were collected quarterly at the three locations shown in figure 1. The results of analysis of these samples are presented in table 2. The average alpha and beta-gamma radioactivity concentrations of stream silt samples were 0.65 pCi/g and 22 pCi/g, respectively, for the first half of 1966. Both of these values are considerably lower than their respective values of 27 pCi/g and 230 pCi/g reported during the last half of 1965. These decreases were likely a result of lower alpha and beta-gamma radioactivity concentrations in the main laboratory and critical facility liquid effluents discharged during the first 6 months of 1966.

Table 2. Radioactivity in stream silt, Bettis January–June 1966

Period 1966	Location [a]	Silt radioactivity (pCi/g)	
		Alpha	Beta-gamma
January–March	A	0.35	74
	B	0.25	16
	C	0.005	14
	Average	0.30	35
April–June	A	0.71	4.4
	B	1.3	12
	C	1.4	12
	Average	1.1	9.5
January–June	Average	0.65	22

[a] See figure 1 for locations.

Semiannual gamma spectra and analyses for strontium-89 and strontium-90 were obtained for composites of quarterly silt samples. Table 3 presents the results of these analyses for samples collected during the second half of 1965. Gamma spectra and analytical results for strontium-89 and strontium-90 for the samples obtained during the first half of 1966 are not yet available and will be included in the report for the second half of 1966.

Table 3. Gamma-emitting radionuclides, strontium-89, and strontium-90 in stream silt (6-month composite), Bettis, July–December 1965

Location [a]	Identified gamma emitters	Concentration (pCi/g of silt)	
		Strontium-89	Strontium-90
A	Potassium-40, and daughters of radium-226.	0.02[illegible]	0.37
B	Zirconium-95, niobium-95, and cobalt-60.	0.027	0.68
C	Potassium-40, and daughters of radium-226.	0.045	0.13

[a] See figure 1 for locations.

Recent coverage in *Radiological Health Data and Reports*:

Period	Issue
January–June 1965	April 1966
July–December 1965	October 1966

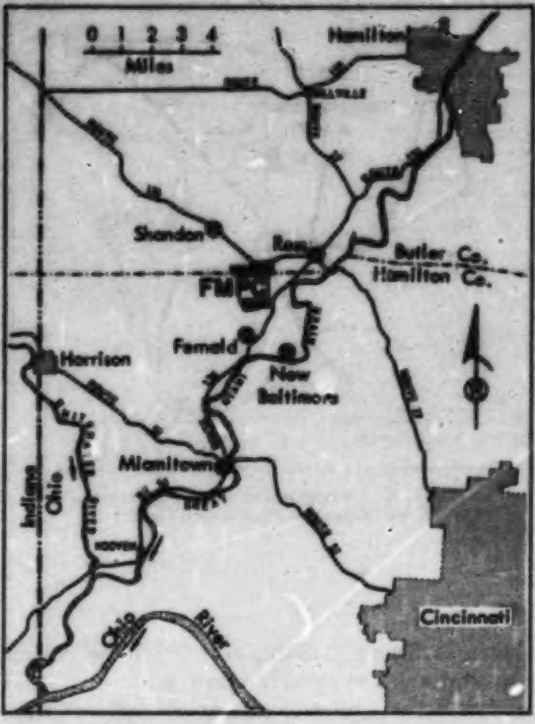


Figure 2. Area map of Feed Materials Production Center

2. Feed Materials Production Center January-June 1966[3]

National Lead Company
Fernald, Ohio

The Feed Materials Production Center (FMPC) is operated by the National Lead Company of Ohio for the AEC. The location as related to populated areas is shown in figure 2. Cincinnati and Hamilton—the larger nearby communities—are situated 20 and 10 miles, respectively, from the Center. FMPC processes high-grade uranium ores and ore concentrates to produce metallic uranium, and fabricates the metal into fuel elements.

An environmental survey program has been established to detect radioactive contaminants of FMPC origin and to evaluate their impact on the surrounding environs. The results of this program, both present and past, indicate that the material released to the environs at this site is below the maximum permissible concentrations (MPC) as recommended by the National Committee on Radiation Protection and Measurements (NCRP) and the State of Ohio.

Air monitoring

Many of the processes at FMPC generate airborne dusts. Specially designed equipment is used to recover particulates released to the air by these processes and to control release of radioactive particulates through the exhaust stacks.

Onsite air samples are obtained from four permanent perimeter air sampling stations, located at the four corners of the production area,

---

[3] Summarized from "Feed Materials Production Center Environmental Monitoring Semi-Annual Report for the First Half of 1966" (NLCO–981).

-50-

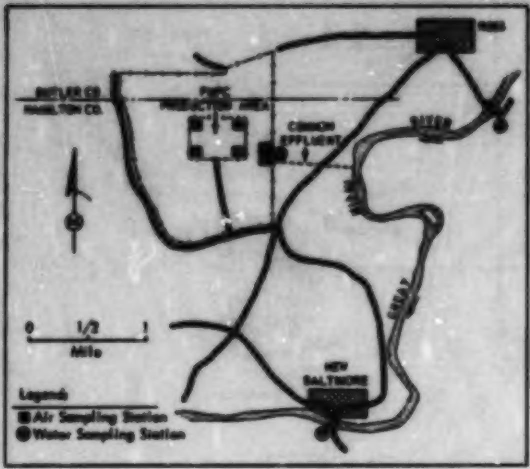


Figure 3. Air and water sampling stations Feed Materials Production Center

shown in figure 3. Samples from these perimeter stations are collected once each week and analyzed for uranium and total radioactivity. Offsite samples are collected by a mobile air sampling unit. The location at which samples are collected is determined by local meteorological conditions on the day of sampling. Approximately 20 percent of all samples are taken upwind of the FMPC plant. Replicate samples are taken at each sampling point and averaged to obtain a representative concentration for that location. Concentrations of uranium and total radioactivity of airborne particulates sampled at onsite and offsite locations are given in table 4.

Water monitoring

Each of the individual production plants on the project has collection sumps and treatment equipment to remove the uranium from the process waste water. The effluent from the plants are collected at a general sump for equalization and settling. The clear water from the sump is pumped to the river. The solid portion is pumped to a chemical waste pit for further settling. The flow, which is decanted to the clear-well portion of the pit, is virtually free of solids and radioactivity. The effluent from the sump and clear-well are combined with waste water from the FMPC water treatment plant, sanitary sewage treatment plant, and storm sewerage system and discharged via a common effluent outfall into the Great Miami River. A weir type of water sampler collects samples of the combined effluent stream, which are removed and analyzed daily. These results and measurements of river flow are used in calculating the radioactive contaminant concentrations added to the river. Weekly spot samples are also obtained upstream and downstream from the common FMPC effluent at locations shown in figure 3. The results of the FMPC water monitoring program for the first half of 1966 are summarized in table 5.

Table 4. Radioactivity levels of airborne particulates, FMPC, January–June 1966

Location	Number of samples	Uranium concentration [a] (pCi/m^3)			Total radioactivity [b] (pCi/m^3)		
		Maximum	Minimum	Average	Maximum	Minimum	Average
Onsite:							
Southwest	25	1.3	<0.1	0.2	2.3	<0.1	0.4
Northwest	25	.2	< .1	.1	.3	< .1	.2
Northeast	25	.3	< .1	.1	1.0	< .1	.3
Southeast	25	.4	< .1	.1	.9	< .1	.2
All onsite samples	[illegible]	1.3	< .1	.1	2.3	< .1	.3
Offsite:							
0–2 miles from FMPC	26	0.5	< .1	< .1	1.1	.1	.3
2–4 miles from FMPC	40	.1	< .1	< .1	.5	.1	.2
4–8 miles from FMPC	32	.3	< .1	< .1	1.0	.1	.2
8–12 miles from FMPC	5	< .1	< .1	< .1	.1	.1	.1
All offsite samples	103	.5	< .1	< .1	1.1	.1	.2

[a] AEC radiation protection standard, 2 pCi/m^3

[b] AEC radiation protection standard, 100 pCi/m^3

-51-

Table 5. Radioactivity in the Great Miami River, FMPC, January–June 1966

Location	Number of samples	Uranium concentration [a] (pCi/liter)			Total radioactivity [b] (pCi/liter)		
		Maximum	Minimum	Average	Maximum	Minimum	Average
Sewer outfall	101	90	<10	2	140	<10	10
Upstream from outfall	26	20	<10	5	90	<10	20
Downstream from outfall	26	20	<10	6	140	<10	20

[a] AEC radiation protection standard, 20,000 pCi/liter
[b] AEC radiation protection standard, 3,000 pCi/liter

Recent coverage in *Radiological Health Data and Reports*:

Period	Issue
January–June 1965	April 1966
July–December 1965	October 1966

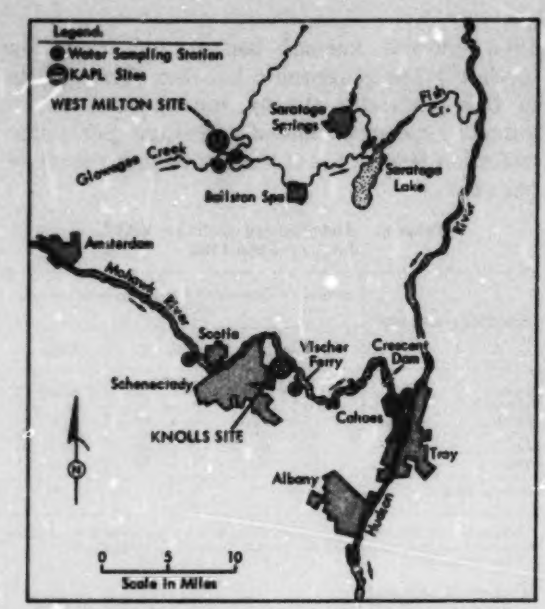


Figure 4. Environmental monitoring locations, KAPL

3. Knolls Atomic Power Laboratory January-June 1966[4]

General Electric Company
Schenectady, New York

The principal function of the Knolls Atomic Power Laboratory (KAPL), operated by the General Electric Company for the Atomic Energy Commission, is to support the Naval Reactors Program of the AEC in the development of atomic power for naval propulsion. This includes design, construction, and prototype operation of nuclear power reactors.

The Knolls Atomic Power Laboratory consists of two sites, the Knolls site and the West Milton site (figure 4). The Knolls site occupies approximately 170 acres on which are located administrative buildings; chemistry, physics, metallurgical, engineering, and radioactive materials laboratories; critical assembly buildings; machine shops, decontamination facilities; radioactive waste storage and processing facilities; and nuclear fuel storage and assembly buildings. The West Milton site occupies approximately 4,000 acres. Its principal facilities include the Triton (S3G) and Bainbridge (D1G), prototype reactors, equipment service building, fuel service building, and waste treatment facilities. Regular environmental monitoring activities are conducted to assure that laboratory releases of radioactivity to the environment are in compliance with AEC standards.

Air monitoring

Environmental airborne radioactivity is measured at two locations on the Knolls site, four locations at the West Milton site, and at the General Electric Company Research Laboratory approximately 1 mile west of the Knolls site. Airborne radioactivity is sampled continuously and analyzed on a weekly basis. Each environmental monitoring station is equipped with film dosimeters to detect integrated gamma radioactivity levels. The average airborne beta and gamma radioactivity at each of the three areas is summarized in table 6 for the 6-month period.

In addition to the environmental airborne radioactivity monitoring, surveys are made semiannually of the radiation levels at the perimeter of KAPL at both the West Milton and Knolls sites. The perimeter survey of June

---

[4] Summarized from "Knolls Atomic Power Laboratory, Semiannual Environmental Monitoring Report, January–June 1966."

1966 showed normal background radiation levels for the geographic location. The results of this perimeter survey, extrapolated to an annual exposure, indicate average perimeter radiation levels of less than one-tenth roentgen per year.

Table 6. Airborne radioactivity, KAPL, January–June 1966

Sampling period 1966	Average radioactivity (beta + gamma) in air[a] (pCi/m³)		
	Knolls site	West Milton	Offsite
January	0.07±0.01[b]	0.06±0.02[b]	0.05±0.01[b]
February	.05± .01	.03± .02	.07± .01
March	.07± .01	.06± .02	.07± .01
April	.07± .01	.09± .02	.07± .01
May	.10± .01	.15± .02	.10± .01
June	.19± .01	.24± .02	.21± .01
January–June	0.0[illegible]	0.11	0.09

[a] Samples are counted a minimum of 48 hours after collection to allow short-lived natural radionuclides to decay to nondetectable levels.
[b] Counting error.

Water monitoring

All potential sources of liquid radioactive waste at the Knolls site are connected by control drains to collection tanks in the radioactive waste-processing building. The release of liquid waste to the Mohawk River is regulated through the monitoring of the concentration of fission products in the collection tanks and the control of the discharge rate of the effluent.

A continuous proportional sample of the Knolls site combined-sewer effluent is taken at the point of discharge to the Mohawk River. Radiochemical analyses of the weekly composite samples show that strontium-90 is the principal radionuclide to be considered in control. The amounts and the radionuclide content of the combined sewer effluent discharged from the Knolls site are summarized in tables 7 and 8.

Mohawk River water is sampled continuously at the point of discharge from the Knolls site; at the General Electric Company powerhouse 8 miles upstream from the site; at the Vischer Ferry powerhouse approximately 2 miles downstream; and at the City of Cohoes pumping station about 13 miles downstream. Results of this sampling along with those for precipitation are given in table 9.

Table 7. Radioactivity (beta + gamma) in the Knolls site liquid waste effluent, January–June 1966

Sampling period 1966	Total radioactivity (millicuries)	Average concentration[a] (pCi/liter)
January	25.3	1.7×10^3
February	13.3	1.3×10^3
March	22.0	2.8×10^3
April	35.8	5.0×10^3
May	18.1	1.5×10^3
June	10.1	0.9×10^3
January–June	124.6	2.0×10^3

[a] Average concentration for the first half of 1966 represents a weighted average of the weekly composite samples collected during the period.

Table 8. Concentration of specific radionuclides in the Knolls site liquid waste effluent, January–June 1966

Radionuclide	Average radionuclide concentration (pCi/liter)	Applicable AEC standard[a]
Cerium-praseodymium-144	13	10,000
Cesium-137	38	20,000
Iodine-131	<2	300
Ruthenium-106	<2	10,000
Strontium-89	<2	3,000
Strontium-90	69	300
Yttrium-90	68	20,000

[a] AEC manual, chapter 0524 "Standards for Radiation Protection" Appendix annex 1 contains the applicable AEC standards.

The Knolls site effluent is sampled continuously for alpha-particle activity. During the first half of 1966 the semiannual discharge rate of alpha-particle emitters was less than 1 percent of the most restrictive AEC radiation protection standards for an alpha-particle emitting radionuclide (5×10^3 pCi/liter for plutonium-239). The radioactivity levels in the liquid waste from the West Milton site are operationally controlled and diluted prior to release into Glowegee Creek. Samples of the creek water are taken once a week at two locations: one is about 150 feet above the point where the S3G effluent enters the creek and the other is about 2,640 feet below the S3G discharge, or 1,500 feet below the D1G discharge. Table 10 presents a summary of radioactive wastes discharged to Glowegee Creek in terms of total radioactivity and concentration in liquid wastes.

Radiochemical analyses of these wastes indicated that strontium-89 and strontium-90 concentrations were less than 2 percent of the respective AEC standards during the reporting period. The average results for unidentified radionuclides in the D1G and S3G effluents (43 and 84 pCi/liter respectively) represent less than 2 percent and less than 3 percent of the applicable AEC radiation protection standard of 3×10^3 pCi/liter.[5]

---

[5] AEC Manual, Chapter 0524 "Standards for Radiation Protection," Appendix Annex 1, Note 3.C, contains the applicable AEC standard.

Table 9 Radioactivity in Mohawk River water and precipitation near the Knolls site, January–June 1966

Sampling period 1966	Average radioactivity (beta + gamma) (pCi/liter)			
	G.E. powerhouse (upstream)	Vischer Ferry (downstream)	Cohoes raw water (downstream)	Precipitation
January	5 ± 4[a]	3 ± 4[a]	6 ± 4[a]	0.2×10^{3}
February	5 ± 4	4 ± 4	3 ± 4	0.3×10^{3}
March	4 ± 4	3 ± 4	3 ± 4	0.3×10^{3}
April	5 ± 4	1 ± 4	1 ± 4	0.3×10^{3}
May	6 ± 4	4 ± 4	4 ± 4	9.2×10^{3}
June	5 ± 4	5 ± 4	7 ± 4	2.0×10^{3}
January–June	5	3	4	2.1×10^{3}

[a] Counting error

Table 10. Radioact'vity (beta + gamma) in West Milton liquid waste effluents, KAPL, January–June 1966

Sampling period 1966	Total radioactivity (millicuries)		Average radioactivity (pCi/liter)	
	D1G effluent	S3G effluent	D1G effluent	S3G effluent
January	0.39	0.05	37	24
February	.47	.08	30	36
March	.61	.33	47	118
April	.69	.23	47	105
May	1.40	.39	69	154
June	.66	.14	26	78
January–June	4.22	1.22	44	86

Table 11 presents the average concentrations of beta-particle and gamma-ray activity detected in Glowegee Creek water upstream and downstream from the S3G and D1G liquid waste outfalls and in precipitation collected during this period.

Table 11. Radioactivity in Glowegee Creek water and precipitation near the West Milton site, KAPL, January–June 1966

Sampling period 1966	Average radioactivity (beta + gamma) (pCi/liter)		
	Glowegee Creek (upstream)	Glowegee Creek (downstream)	Precipitation
January	4 ± 7[a]	12 ± 7[a]	0.4×10^{3}
February	9 ± 7	2 ± 7	0.2×10^{3}
March	9 ± 7	12 ± 7	1.1×10^{3}
April	10 ± 7	7 ± 7	1.5×10^{3}
May	12 ± 7	2 ± 7	1.6×10^{3}
June	14 ± 7	15 ± 7	2.8×10^{3}
January–June	10	8	1.3×10^{3}

[a] Counting error

Recent coverage in *Radiological Health Data and Reports*:

Period	Issue
January–June 1965	April 1966
July–December 1965	October 1966

4. S1C Prototype Reactor Facility January-June 1966[a]

Combustion Engineering, Inc.
Windsor, Connecticut

The S1C Prototype Reactor Facility is a land-based nuclear submarine power plant operated for the Atomic Energy Commission by the Naval Reactors Division of Combustion Engineering, Inc. The prototype contains a pressurized water reactor power plant which is used to conduct research and development work and to train personnel in the operation of naval reactor power plants. Reactor power operations at the S1C Prototype Facility began in December 1959.

The low-level radioactive waste discharged intermittently from S1C prototype operations consists mainly of water. Small quantities of airborne particulates in gaseous waste are also generated and released on occasion in the ventilation exhaust air.

Essentially, all of the radioactive waste originates from the activation of minute amounts of impurities or corrosion products in the circulating water used as a reactor coolant. All materials released to the environment are routinely monitored to assure that waste disposal operations comply with AEC regulations.

---

[a] Summarized from "S1C Prototype Reactor Facility Environmental Monitoring Report, January 1 through June 30, 1966" (CENRD-3163-RS-544).

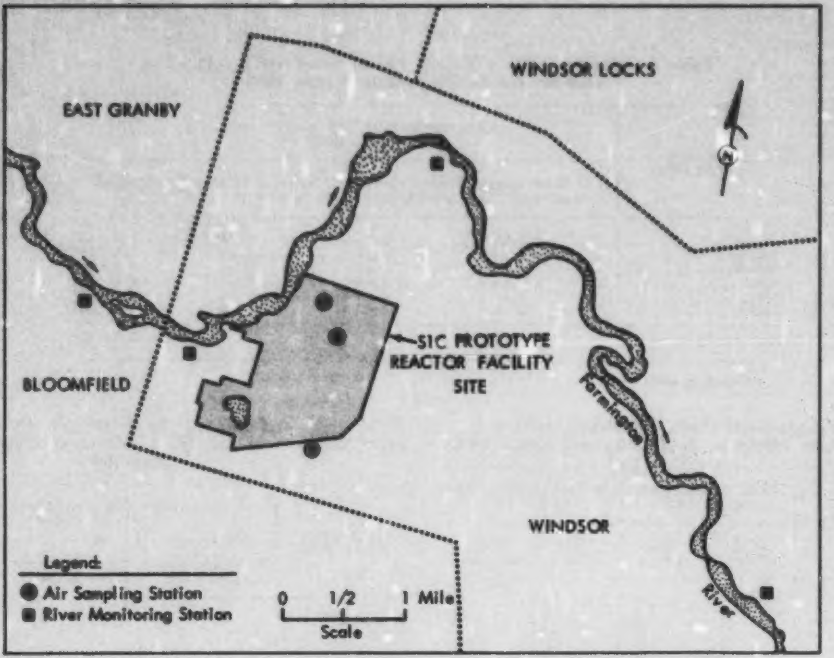


Figure 5. Environmental monitoring locations, S1C Prototype site

Air monitoring

Ventilation air from the submarine hull and the supporting facility at the prototype site may contain small amounts of radioactive gases or particulates. This ventilation air is discharged to the environment through an exhaust stack. The ventilation air is continuously monitored for radioactivity by automated counters which control the discharge of the exhaust air. When the AEC maximum permissible concentration limits are exceeded, the exhaust air is discharged through a high-efficiency filter bank or the ventilation system is completely shut down and the hull sealed. In addition, air is continuously sampled for particulates at onsite and offsite locations shown in figure 5. Table 12 presents the average gross beta-particle activity concentrations detected at air-monitoring stations during the first and second quarters of 1966.

Water monitoring

Liquid wastes are collected in 5,000-gallon retention tanks. If the radioactivity in a filled tank is below the allowable AEC limit for discharge to uncontrolled areas, the tank contents are released into the industrial waste system. If the limit is exceeded, the contents are diluted below the applicable AEC radiation protection standard in a 25,000-gallon dilution tank and then released. Table 13 is a summary of the gross beta-particle activity released to the Farmington River during the first half of 1966.

Table 12. Gross beta-particle activity in continuous air samples S1C, January–June 1966

Sampling location	Beta radioactivity concentration (pCi/m^3)					
	January–March			April–June		
	Minimum	Maximum	Average	Minimum	Maximum	Average
Stack and hull exhausts	36	75	58	28	92	60
Onsite stations	0.12	2.1	0.40	0.11	5.5	0.25
Offsite stations	0.11	3.0	0.30	0.12	0.65	0.20

Table 13. Gross beta-particle activity released to the Farmington River, S1C, January–June 1966

Period	Total radioactivity (millicuries)	Average concentration (pCi/liter)
January–March	1.16	4.8×10^2
April–June	9.24	3.3×10^3

The concentrations of specific radionuclides released to the river during this period are presented in table 14.

Table 14. Concentration of specific radionuclides released to the Farmington River, SIC, January–June 1966

Radionuclide	Average concentration for Jan–June 1966 (pCi/liter)	Applicable AEC Standard * (pCi/liter)
Cobalt-60	3.5×10^3	3×10^4
Iron-59	5.2×10^1	6×10^4
Manganese-54, cobalt-58	4.1×10^0	9×10^4

* AEC manual, Chapter 0524, "Standards for Radiation Protection" Appendix Annex 1, contains the applicable AEC standard.

The Farmington River is sampled periodically at various locations as shown in figure 5 for determination of gross beta-particle activity in river water and mud. All 30 water samples contained less than the detectable level of 10 pCi/liter of gross beta-particle activity. All 11 mud samples contained less than the detectable level of 10 pCi/g of gross beta-particle activity.

Recent coverage in *Radiological Health Data and Reports*:

Period	Issue
January–June 1965	April 1966
July–December 1965	October 1966

-56-

Section V. Technical Notes

REPORTED NUCLEAR DETONATIONS, MARCH 1967

During March 1967, the Atomic Energy Commission announced one nuclear test conducted at the Nevada Test Site. This underground nuclear test was conducted on March 2 and was low yield (less than 20 kilotons TNT equivalent).

-57-

SYNOPSES

Synopses of reports, incorporating a list of key words, are furnished below in reference card format for the convenience of readers who may wish to clip them for their files.

PLUTONIUM–239 IN TOTAL DIET AND MILK. *P. E. Kauffman* and *P. J. Magno.* Radiological Health Data and Reports, Vol. 8, April 1967, pp. 191–194.

The National Center for Radiological Health initiated a program in July 1965 to determine the level of plutonium–239 in the total diet and milk. The diet samples were obtained from the Institutional Total Diet Sampling Network of the Public Health Service, and the milk samples were obtained from the PHS Pasteurized Milk Network. Using a gastrointestinal absorption factor of 3×10^{-5} as suggested by the International Commission on Radiological Protection, the average amount of plutonium–239 reaching the blood stream from the diet is estimated to be 2×10^{-4} femtocuries per day.

KEY WORDS: diet, foods, Institutional Total Diet Sampling Network, milk, Pasteurized Milk Network, plutonium–239, plutonium–240.

ERRATA

The last sentence of the last paragraph, column 1, (Radiol Health Data Rep 7:683, December 1966), which begins "It is not surprising . . ." should read "It is not surprising that the concentrations of cesium-137 and strontium-90 in Palmer milk are similar to the Pasteurized Milk Network averages (*18*)."

In the February 1967 issue, the amount of xenon-133 released to the atmosphere from the Shippingport Atomic Power station was incorrectly reported (Radiol Health Data Rep 8:133, February 1967), and should read, "During the first half of 1966, a total of 30.4 μCi of xenon-133 was released at Shippingport at concentrations less than the MPC of 3×10^5 pCi/m^3."

The last equation appearing in the article "Precision and Sensitivity of Gamma Spectrometric Measurements in Milk" (Radiol Health Data Rep 7:555-559, October 1966) should be amended. The second part of equation (6) on page 556 should read as follows:

$$\text{“}s_I^2 = \text{variance of } (G_I - B_I) = (G_I + B_I)/t\text{”}$$

The following corrections should be made in the article "Radionuclide Levels in Milk, Total Diet, and Human Bone Compared to Federal Radiation Council Estimates, 1965, and 1966

(*Continued on next page*)

Estimates" (Radiological Health Data and Reports 8:65-72, February 1967).

1) Page 67, equation (1)—R=average monthly strontium-90 fallout rate (mCi/mi² • month).
   b=4.7 x 10^{-3} mi² • month/g Ca (*8*).
2) Page 67, in several places the unit m² is shown and should be mi²—206 mCi/mi², (0.33 mCi/mi² • month), 5.4 mCi/mi², 3 mCi/mi².
3) Page 68, the last sentence of the paragraph "Strontium-90" should read:
   "The network annual average intakes were 13 pCi/day in 1962, 25 pCi/day in 1963, and 32 pCi/day in 1964, corresponding to approximately 12, 22, and 28 pCi/g Ca, respectively."[3]
4) Page 71, equation (3)—D=dose (rads/year)
   11=conversion constant (kg-rads/mCi-year)

☆ U.S. Government Printing Office: 1967—252807/9

RADIOLOGICAL HEALTH DATA AND REPORTS

Volume 8, Number 5, May 1967

In August 1959, the President directed the Secretary of Health, Education, and Welfare, to intensify Departmental activities in the field of radiological health. The Department was assigned responsibility within the Executive Branch for the collation, analysis, and interpretation of data on environmental radiation levels such as natural background, radiography, medical and industrial uses of isotopes and X rays, and fallout. The Department delegated this responsibility to the National Center for Radiological Health, Public Health Service.

***Radiological Health Data and Reports*, a monthly publication of the Public Health Service, includes data and reports provided to the National Center for Radiological Health by Federal agencies, State health departments, and foreign governmental agencies. Pertinent original data and interpretive manuscripts are invited from investigators.**

The Federal agencies listed below appoint their representatives to a Board of Editorial Advisors. Members of the Board advise on general publications policy; secure appropriate data and manuscripts from their agencies; and review those contents which relate to the special functions of their agencies.

Department of Defense
Department of Agriculture
Department of Commerce
Department of Health, Education, and Welfare
Atomic Energy Commission

CONTENTS

REPORTS

Page

Radiation Hazards from X-ray Diffraction Equipment 245
J. R. Howley and *C. Robbins*

DATA

SECTION I. MILK AND FOOD 251

National and International Milk Surveillance 251

1. Pasteurized Milk Network, January 1967, *PHS* 252
2. Canadian Milk Network, January 1967 258
3. Pan American Milk Sampling Program, January 1967, *PAHO* and *PHS* 259

State Milk Surveillance Activities 260

1. Connecticut Milk Network, October–December 1966 261
2. Indiana Milk Network, October–December 1966 262
3. Michigan Milk Network, October–December 1966 263
4. Minnesota Milk Network, October–December 1966 265
5. New York Milk Network, October–December 1966 267
6. Pennsylvania Milk Network, October–December 1966 269

Food and Diet Surveillance Activities 271

1. Estimated Daily Intake of Radionuclides in California Diets, May–August 1966 271

CONTENTS—continued

Page

2. Estimated Daily Intake of Radionuclides in Connecticut Standard Diet, July–December 1966 274

SECTION II. WATER 277

Gross Radioactivity in Surface Waters of the United States November 1966 278

SECTION III. AIR AND DEPOSITION 281

1. Radiation Surveillance Network, January 1967, *PHS* 282
2. Canadian Air and Precipitation Monitoring Program, January 1967 285
3. Mexican Air Monitoring Program, January 1967 287
4. Pan American Air Sampling Program, January 1967 *PAHO* and *PHS* 287
5. Plutonium in Airborne Particulates, October–December 1966, *PHS* 288

SECTION IV. OTHER DATA 290

Radionuclides in Alaskan Caribou and Reindeer, October–November 1966, *PHS* 290

Environmental Levels of Radioactivity at Atomic Energy Commission Installations 292

1. Mound Laboratory, January–June 1966 292
2. Rocky Flats Plant, July–December and Annual Summary 1966 294

SECTION V. TECHNICAL NOTES 296

Radiological Monitoring of the Native Texas Commercial Oyster 296
J. J. Stanko and *M. C. Wukasch*

Strontium-90, Cesium-137, and Polonium-210 in Human Tissues . 298
E. J. Baratta and *E. S. Ferri*

Reported Nuclear Detonations, April 1967 299

Synopses iii

Symbols, Units, and Equivalents .... Inside back cover

RADIOLOGICAL HEALTH DATA AND REPORTS

Published under the direction of

James G. Terrill, Jr., Director and
Dr. Raymond T. Moore, Deputy Director
National Center for Radiological Health

by the Standards and Intelligence Branch
National Center for Radiological Health
Donald L. Snow, Chief

BOARD OF EDITORIAL ADVISORS

Dr. Hugh B. Mitchell
Department of Defense
Dr. Ronald G. Menzel
Department of Agriculture
Dr. Wilfrid B. Mann
Department of Commerce
Robert E. Simpson
Food & Drug Administration, DHEW
John A. Harris
Atomic Energy Commission

STAFF

Managing Editor
Samuel Wieder
Assistant Managing Editor
Charles F. Coyle
Senior Technical Editor
Marvin Rosenstein
Technical Editors
Kurt L. Feldmann
Richard Wromble

Illustrator
Marylee Hill

Address correspondence to the Managing Editor, *Radiological Health Data and Reports*, National Center for Radiological Health, Public Health Service, Rockville, Maryland 20852.

For subscriptions to *Radiological Health Data and Reports*, please use the order form on last page of this issue.

U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service ● National Center for Radiological Health

Reports

Radiation Hazards from X-ray Diffraction Equipment

J. R. Howley and *C. Robbins*[1]

Improper or careless use of X-ray diffraction equipment can cause severe burns to the upper extremities of the body of the operator. These burns are slow to heal and can lead to cancer. Cataracts and other opacities can be produced in the eye with a single exposure of 200 roentgens. The use of inadequate survey equipment can lead to a gross underestimate of the hazard. Since serious injury from intense primary beam radiation can occur in a matter of seconds and the hazard from scattered radiation is also significant, the use of film badge monitoring alone can give a false sense of protection. Recommendations are given.

X-ray diffraction has become a powerful industrial and medical research tool for the study of solids and liquids. Every day thousands of X-ray diffraction patterns are made for the analysis of practically every conceivable material known to man.

Although much has been reported on technical accomplishments with the use of this equipment, relatively little has been said concerning its hazards. Most of the texts on X-ray crystallography make no mention of the very high exposure rates ranging up to one million roentgens per minute from the primary beam of an X-ray diffraction unit. In the hands of a careless or uninformed person, this unit becomes a very dangerous instrument.

The most frequently reported injury from this equipment is severe burns to the upper extremities of the body (*1–6*). These burns are slow to heal and can lead to cancer. Injuries usually result from carelessness or a failure to fully appreciate the hazards involved.

A second type of injury to be expected is the formation of very small cataracts and other opacities in the lens of the eye (*7–10*). This injury is difficult to relate to cause since the cataracts or opacities may be delayed as much as 5 years after exposure. An occasional report of this type of injury among crystallographers should not come as a surprise, after a consideration of the following epidemiological observations.

Desjardins (*7*) in 1931 noted the sensitivity of the adult lens of the eye to X radiation. Colwell (*8*) in 1934 concluded that there is a danger of opacity in the lens when an eye has received a full erythema dose, irrespective of the quality of the radiation. Quimby's data (*11*) in 1952 showed how the threshold exposure for erythema decreases with the energy of the radiation. Merriam and Focht (*9*) in 1957 studied the incidence of cataracts as a side effect of therapeutic radiation, and reported a minimum cataractogenic exposure of 200 roentgens for single-treatment therapy. For extended treatments from 3 weeks to 3 months, they report a minimum nearer 400 R (figure 1).

---

[1] Mr. Howley and Mr. Robbins are health physicists, Radiation Safety Section, Department of Nuclear Medicine, National Institutes of Health, Bethesda, Md. 20014.

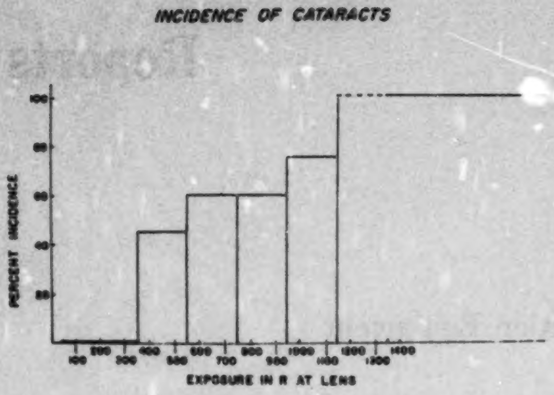


Figure 1. Percentage incidence of cataracts of the eye at varying x-ray exposures

The problem

The radiation hazards around X-ray diffraction equipment vary with the type of operation and the vintage of the equipment. One very common arrangement is an X-ray tube enclosed in a protective housing which has four ports, each port having a manually operated cover (figure 2). If the unit is energized and these covers are lifted, X rays escape. Without the protective interlocks and shutters of the more recently designed units (*12–16*), the unwary can manipulate the beam stopper and the X-ray diffraction camera while exposed to radiation. This procedure is done to avoid interrupting an exposure to cameras set up on the other ports. This operation is not recommended but occurs more often than users care to admit. X-ray films exposed near the unit show a varied pattern of scattered radiation near the X-ray tube port and powder camera. This presents a problem in selecting monitoring equipment for such heterogeneous scattered radiation, since ion chambers must be fully covered by a uniform radiation field for proper operation.

Method

McLaughlin and Blatz (*15*) reported using detectors readily available to the health physicist in their studies of X-ray diffraction radiation hazards. They felt correction factors as high as 2 might be necessary for their data, based on Day's study of soft X-ray measurements with thimble chamber r-meters.

T. H. Rogers (*17*) and other investigators (*18–20*), in discussing the measurements of high-intensity radiation from beryllium window X-ray tubes, have drawn attention to the necessity for extremely thin-walled chambers in r-meters, in order to obtain results comparable to a standard free-air chamber.

The present study compares several types of radiation detectors (table 1) for the measurement of incident and scattered X rays, with considerable variation in results. Small thermoluminescent rod and disc dosimeters, calibrated in the incident beam with thin end-window r-meters, gave better results. The end-window r-meters (2,500 R and 250 R) were found the most satisfactory of the instruments to work with because of the small size, window thickness, and ease of handling. These r-meters are factory calibrated with free-air chambers for energies below 35 keV.

Table 1. Dose rate measurements with various meters

Distance (cm)	Angle (°)	R-meter Victoreen thin end-window Model 651-2 (mR/hr)	Victoreen Model 440		Cutie Pie Tracerlab Model SUIH	
			(mR/hr)	(Percent of r-meter)	(mR/hr)	(Percent of r-meter)
40	45	375	250	67	89	24
60	90	600	150	25	45	8
60	120	3,900	220	5.6	400	10

Large sheets of calibrated X-ray film placed about the diffraction unit added considerably to a thorough evaluation of the scattered radiation. Dental size dosimeter film exhibited a flatter calibration curve and would be preferable, particularly if it could be obtained in large sheets.

Findings

The intensity of the incident X-ray beam, known to be large, was measured in the following manner: a 2,500-roentgen thin end-window chamber was located at various positions along the axis of the incident X-ray beam and the exposure rates recorded. The data obtained by this experiment were plotted (figure 3). A linear extrapolation leads to a value of 400,000 R/min at the X-ray tube port. This exposure rate is typical for a unit operating at 50 kilo-

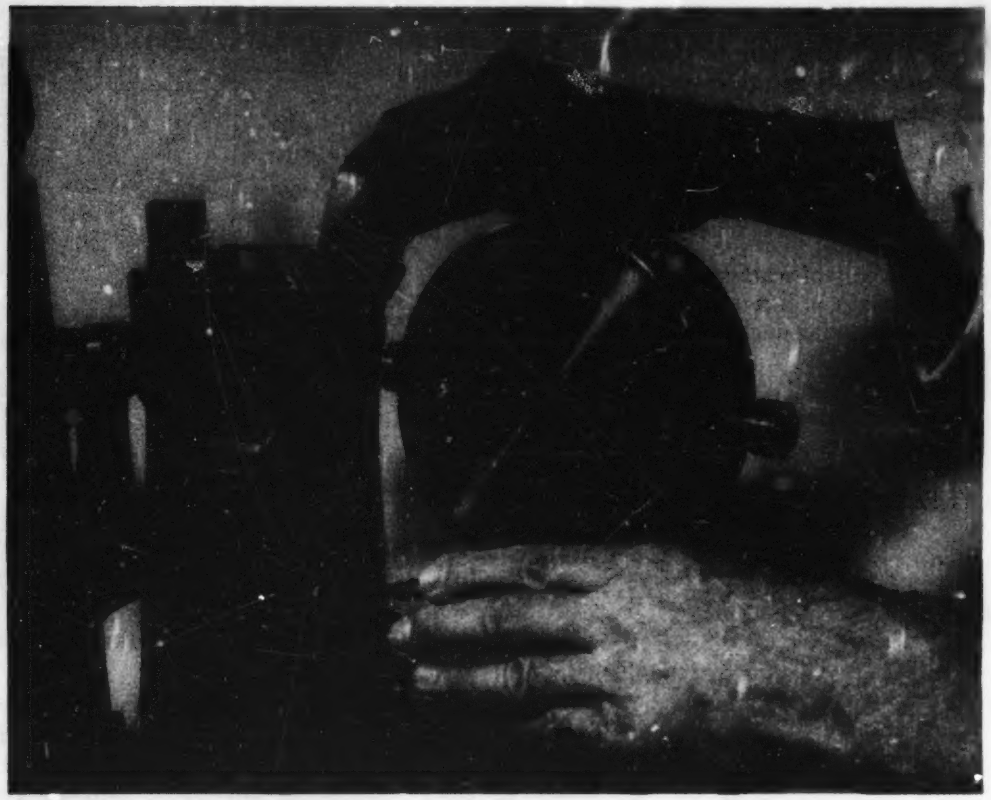


Figure 2. X-ray diffraction tube port and camera

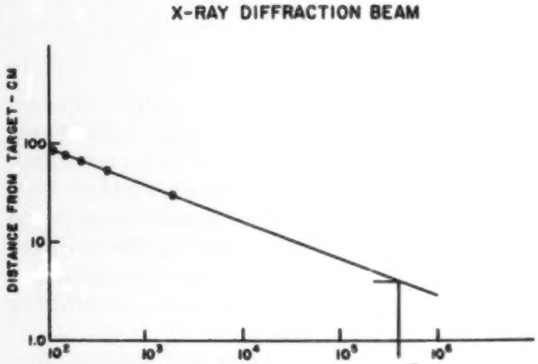


Figure 3. Results of incident beam measurement

volts, 20 millamperes, and with minimum inherent filter of approximately 1 millimeter of beryllium. This agrees substantially with values reported by others (*17, 20*). The half-value layer of the beam was 0.05-mm aluminum corresponding to an equivalent energy of 8 keV. The addition of a 0.0007-inch (0.0175 mm) nickel filter, commonly used in X-ray diffraction, reduced the extrapolated value of the exposure in the incident beam at the X-ray tube port to 200,000 R/min.

The energy of the scattered radiation was taken to be equal to the energy of the incident beam, since the measured half-value layer of 90° scattered radiation was 0.05 mm of aluminum, corresponding to the same energy obtained for the incident beam. The energy of the scattered radiation due to Compton interactions is essentially the same as the incident beam as seen from the following calculation for 8 keV:

$$E' = \frac{E}{1+\alpha(1-\cos\phi)} \qquad (1)$$

where E' = energy of scattered beam,
E = energy of incident beam,
ϕ = scattering angle,
$\alpha = \frac{E}{M_0 c^2}$
M_0 = rest mass of an electron,
and c = velocity of light.

For an incident X-ray beam with an 8 keV energy:

$$\alpha = \frac{E}{M_0c^2} = \frac{0.008 \text{ MeV}}{0.511 \text{ MeV}} = 0.016$$

and equation (1) becomes,

$$E' = \frac{E}{1+0.016\,(1-\cos\phi)}.$$

Since the half-value layer of the scattered radiation was found to be the same as the incident beam, the characteristic radiation due to photoelectric interactions is either equivalent to 8 keV, insignificant, or not measured. For these reasons we felt justified in using the incident beam to calibrate film and other radiation detectors to be used for monitoring scattered radiation.

The manipulation shown in figure 2 for an unfiltered beam resulted in an exposure rate from scattered radiation of 2.0 R/hr to the fingers of the left hand, 50 R/hr to the fingers of the right hand, and 150 mR/hr to the head. The radiation field around the camera is unsymmetrical. When the camera is 10 cm from the X-ray tube port, the exposure rate at 10 cm from the face of the camera varies from 15 R/hr at 45° to 25 R/hr at 90°, and 150 R/hr at 135° from the direction of the primary X-ray beam (figure 4).

Conclusions

From a study of the X-ray diffraction equipment, the intensity of the X-ray beam, and the hazards involved, the following conclusions were made:

a. film badges give the individual a false sense of protection;

b. serious injury can occur within a matter of seconds; and

c. the hazard from scattered radiation can be significant.

Film badges are most useful where the radiation is diffuse and the intensity of radiation is low enough so that a monthly reporting is sufficient warning of impending danger. The intensity of X-ray diffraction exposures can be such that permanent damage will be done before the worker is even aware of his danger. Burns from scattered radiation reported in the literature were due to intensities similar to the ones observed around the units used in this study.

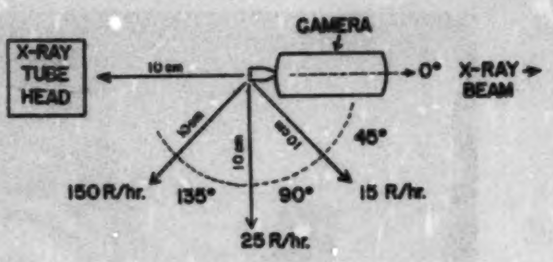


Figure 4. Scattered radiation from the camera

Recommendations

Responsible investigators should conduct thorough radiation surveys and indoctrinate personnel who work in the area and post standard operating procedures. In establishing these procedures, serious consideration should be given to the use of remotely controlled shutters and interlocks (*12–14*), protective goggles, appropriate shielding, and frequent monitoring with suitable equipment.

The variety of procedures and systems used by X-ray diffraction workers will require considerable study in order to establish the special protection requirements for each installation.

Acknowledgements

The authors are grateful to Robert W. Swain of the National Cancer Institute; J. M. Brown, Jr., radiation safety officer at the National Institutes of Health; and Dr. Marie U. Nylen and staff of the National Institute of Dental Research, for their suggestions and assistance in gathering the material for this paper.

REFERENCES

(*1*) BURDICK, K. G. Radiodermatitis due to exposure in industry. JAMA 188:607-608 (May 1964).

(*2*) BAIN, J. T. B. X-ray burns in industry. British Med J 1:1476-1477 (May 1962).

(*3*) COMMISSION ON CRYSTALLOGRAPHIC APPARATUS. Radiation hazards associated with x-ray diffraction techniques. Acta Crystallographica (Denmark) 16:324-328 (April 10, 1963).

(*4*) WATROUS, R. M., H. W. HODGES, and M. J. McANDREW. Radiation burns from diffraction apparatus simulating infections. JAMA 152:513 (1953).

(*5*) McBRIDE, W. W. Radiodermatitis from diffraction apparatus. Arch Environ Health 4:191–195 (February 1962).

(*6*) ARCHER, V. E. Report of x-ray diffraction burn at NIH. National Institutes of Health, Radiation Safety File, Bethesda, Md. 20014 (1955).

(*7*) DESJARDINS, A. U. Action of roentgen rays and radium on the gastro-intestinal tract; experimental data and clinical radiotherapy. Amer J Roentgenol 26:151-190 (1931).

(*8*) COLWELL, H. A. X-ray and Radium Injuries. Oxford University Press (1934), p. 148.

(*9*) MERRIAM, G. R., and E. F. FOCHT. Clinical study of radiation cataracts and the relationship to dose. Amer J Roentgenol Rad Ther Nucl Med 77:759-785 (May 1957).

(*10*) HAYE, C., H. JAMMEL, and M. A. DOLFUS. L'Oeil et les Radiations Ionisantes, Vol. 1 (1965).

(*11*) QUIMBY, E. H. Physical Foundations of Radiology, 2nd Edition, Hoeber, New York, N.Y. (1952).

(*12*) KENNARD, O., and A. J. P. MARTIN. Labyrinth radiation trap for use with standard x-ray diffraction equipment. J Sci Instr 36:48 (January 1959).

(*13*) HUGHES, W. Simple shutter-closing device for x-ray tubes. J Sci Instr 39:93 (1962).

(*14*) BARNES, D. C., and A. FRANKS. Safety shutter for crystallographic x-ray tubes. J Sci Instr 39:648 (1962).

(*15*) McLAUGHLIN, J. E., and H. BLATZ. Potential radiation hazards in the use of x-ray diffraction equipment. Amer Ind Hyg Assoc Quart 16:108-112 (June 1955).

(*16*) DAY, FRANK H. Thimble chamber calibration on soft x-rays. J Res Nat Bur Std 41:399 RP 1926 (October 1948).

(*17*) ROGERS, T. H. (Machlett Laboratory, Inc.). High intensity radiation from beryllium window x-ray tubes. Read before the Thirty-Second Annual Meeting of the Radiological Society of North America, Chicago, Ill. (December 1-6, 1946).

(*18*) TAYLOR, L. S., and C. F. STONEBURNER. The measurement of low voltage X-ray intensities. J Res Nat Bur Std 9:769-780 (1932).

(*19*) VICTOREEN, J., E. D. TROUT, and Z. J. ATLEE. The behavior of thimble chambers when used for the measurement of very soft radiation. Amer J Roentgenol 53:391-394 (1945).

(*20*) QUIMBY, E. H., and E. F. FOCHT. Dosage measurements in contact roentgen therapy. Amer J Roentgenol 50:653-658 (1943).

SECTION I. MILK AND FOOD

In the determination of the internal exposure to man from environmental radiation sources, primary interest centers on radionuclides in the diet. Efforts are being made by both Federal and State agencies to monitor the intake of various radionuclides in the total diet on a continuing basis. The total diet is the most direct measure of intake of radionuclides; however, because specific dietary data are not readily available, indicator foods may be used to estimate radionuclide intake.

Fresh milk is consumed by a large segment of the U.S. population. It contains most of the biologically significant radionuclides from nuclear test debris which appear in the diet, and is the major source of dietary intake of short-lived radionuclides. For these reasons, it is the single food item most often used as an indicator of the population's intake of radionuclides. In the absence of specific dietary information, one may assume that the total daily dietary intake of selected radionuclides is equivalent to the intake represented by the consumption of 1 liter of milk. More direct estimates of dietary intake of radionuclides than those furnished by indicator foods can be obtained by analysis of the total diet or representative principal food items or groups, combined with appropriate consumption data.

The Federal Radiation Council (FRC) has developed Radiation Protection Guides (RPG's) for controlling normal peacetime nuclear operations, assuming continuous exposure from intake by the population at large (*1–3*). The RPG's do not and cannot establish a line which is safe on one side and unsafe on the other; they do provide an indication of when there is a need to initiate careful evaluation of exposure (*3*). Additional guidelines are provided by the FRC Protective Action Guides (*4*) and by the International Commission on Radiological Protection (*5–6*).

Data from selected national, international, and State milk and food surveillance activities are presented herein. An effort has been made to present a cross-section of routine sampling programs which may be considered of a continuing nature. Routine milk sampling has been defined as one or more samples collected per month.

REFERENCES

(*1*) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, Report No. 1. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (May 13, 1960).

(*2*) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (September 1960).

(*3*) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, protective action for strontium–89, strontium–90, and cesium–137, Report No. 7. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (May 1965).

(*4*) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, Report No. 5. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (July 1964).

(*5*) INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION. Recommendation of the International Commission on Radiological Protection, Report No. 2. Pergamon Press, New York, N. Y. (1959).

(*6*) INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION. Recommendation of the Internationl Commission on Radiological Protection, Report No. 6. Pergamon Press, New York, N. Y. (1965).

National and International Milk Surveillance

As part of continuing efforts to quantitatively monitor man's exposure to radionuclides, various national and international organizations routinely monitor radionuclide levels in milk.

-67-

1. Pasteurized Milk Network
January 1967

National Center for Radiological Health and *National Center for Urban and Industrial Health, PHS*

The Public Health Service's Pasteurized Milk Network (PMN), was designed to provide nationwide surveillance of radionuclide concentrations in milk through sampling from major milk production and consumption areas. The present network of 63 stations (figure 1) provides data on milk in every State, the Canal Zone, and Puerto Rico. The most recent description of the sampling and analytical procedures employed by the PMN appeared in the December 1966 issue of *Radiological Health Data and Reports* (*1*).

Table 1. Analytical errors associated with determinations of radionuclide concentrations in milk

Nuclide	Concentration (pCi/liter)	Error ᵃ (pCi/liter)	Concentration (pCi/liter)	Error ᵃ (percent of concentration)
Iodine-131	Less than 100	10	100 or greater	10
Barium-140	Less than 100	10	100 or greater	10
Cesium-137	Less than 100	10	100 or greater	10
Strontium-89	Less than 50	5	50 or greater	10
Strontium-90	Less than 20	2	20 or greater	10

ᵃ Two standard deviations.

Table 1 shows the approximate analytical errors (including counting error) associated with determinations of radionuclide concentrations in milk. These errors were determined by comparing results of a large number of replicate analyses. The results for January 1967 and the fourth quarter of 1966 are presented in table 2. Barium–140 concentrations for all stations were below the limits of detectability. The average monthly radionuclide concentrations are based on results obtained from samples collected weekly. If radionuclide values were below minimum detectable concentrations (*1*), averages were calculated using one-half the mini-

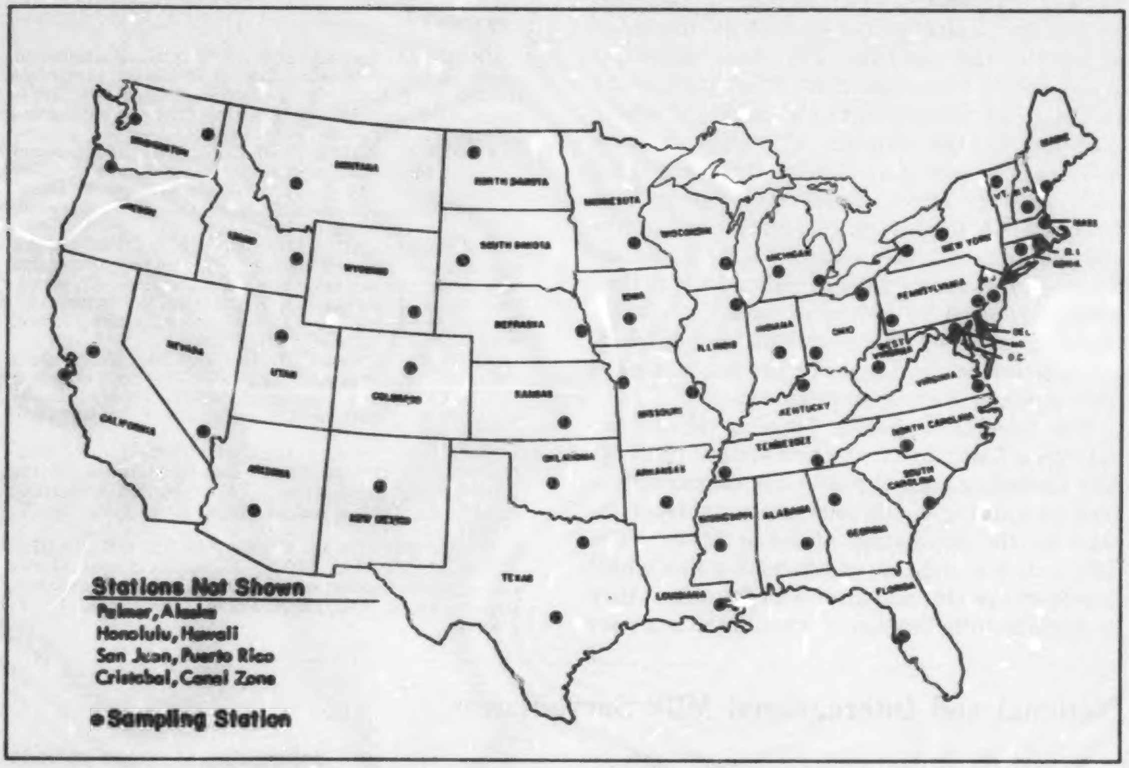

WASHINGTON
OREGON
CALIFORNIA
NEVADA
IDAHO
MONTANA
WYOMING
UTAH
ARIZONA
COLORADO
NEW MEXICO
NORTH DAKOTA
SOUTH DAKOTA
NEBRASKA
KANSAS
OKLAHOMA
TEXAS
MINNESOTA
IOWA
MISSOURI
ARKANSAS
LOUISIANA
WISCONSIN
ILLINOIS
MICHIGAN
INDIANA
OHIO
KENTUCKY
TENNESSEE
MISSISSIPPI
ALABAMA
GEORGIA
FLORIDA
SOUTH CAROLINA
NORTH CAROLINA
VIRGINIA
WEST VIRGINIA
PENNSYLVANIA
NEW YORK
MAINE
VT.
N.H.
MASS
R.I.
CONN.
N.J.
DEL.
MD.
D.C.
Stations Not Shown
Palmer, Alaska
Honolulu, Hawaii
San Juan, Puerto Rico
Cristobal, Canal Zone
● Sampling Station

Figure 1. Pasteurized Milk Network sampling stations

Table 2. Average concentration of radionuclides in pasteurized milk for fourth quarter 1966 and January 1967

Sampling location		Strontium-89 (pCi/liter)		Strontium-90 (pCi/liter)		Iodine-131 (pCi/liter)		Cesium-137 (pCi/liter)	
		Fourth quarter 1966	Jan 1967	Fourth quarter 1966	Jan 1967	Fourth quarter 1966	Jan 1967	Fourth quarter 1966	Jan 1967
Ala:	Montgomery	< 5	< 5	10	11	0	30	15	20
Alaska:	Palmer	< 5	< 5	14	11	0	0	25	20
Ariz:	Phoenix	< 5	< 5	3	3	0	0	5	10
Ark:	Little Rock	5	< 5	24	24	0	0	20	20
Calif:	Sacramento	< 5	< 5	3	3	0	20	5	10
	San Francisco	< 5	< 5	3	6	0	0	10	< 5
C.Z.:	Cristobal	< 5	< 5	5	7	0	0	25	35
Colo:	Denver	< 5	< 5	8	8	0	0	10	5
Conn:	Hartford	< 5	NA	10	10	0	0	20	20
Del:	Wilmington	< 5	NA	12	11	0	10	20	20
D.C.:	Washington	< 5	< 5	12	12	0	0	15	15
Fla:	Tampa	10	< 5	10	10	0	10	95	70
Ga:	Atlanta	5	< 5	16	18	0	30	25	25
Hawaii:	Honolulu	< 5	< 5	4	3	0	0	15	15
Idaho:	Idaho Falls	< 5	< 5	9	6	0	0	15	10
Ill:	Chicago	< 5	< 5	8	8	0	0	15	20
Ind:	Indianapolis	< 5	< 5	10	9	0	0	15	30
Iowa:	Des Moines	< 5	< 5	9	8	0	0	15	15
Kans:	Wichita	< 5	< 5	14	9	0	0	10	10
Ky:	Louisville	10	< 5	13	15	0	0	10	15
La:	New Orleans	< 5	< 5	27	25	0	0	35	35
Maine:	Portland	< 5	< 5	14	13	0	0	45	45
Md:	Baltimore	< 5	< 5	11	12	0	0	15	20
Mass:	Boston	< 5	< 5	13	13	0	0	35	40
Mich:	Detroit	< 5	NA	10	9	0	10	15	20
	Grand Rapids	< 5	< 5	12	11	0	0	20	20
Minn:	Minneapolis	< 5	< 5	21	14	0	0	15	15
Miss:	Jackson	15	< 5	17	23	0	30	15	20
Mo:	Kansas City	< 5	< 5	11	9	0	10	10	10
	St. Louis	< 5	< 5	12	11	0	0	15	15
Mont:	Helena	< 5	< 5	12	8	0	0	20	15
Nebr:	Omaha	< 5	< 5	10	11	0	0	10	10
Nev:	Las Vegas	< 5	< 5	3	3	0	0	10	10
N.H:	Manchester	< 5	< 5	15	16	0	0	45	45
N.J:	Trenton	< 5	< 5	10	10	0	0	20	25
N. Mex:	Albuquerque	< 5	< 5	4	5	0	0	5	5
N.Y:	Buffalo	< 5	< 5	9	10	0	0	20	25
	New York	< 5	< 5	12	12	0	0	25	20
	Syracuse	< 5	< 5	9	9	0	10	20	25
N.C:	Charlotte	< 5	< 5	20	19	0	0	20	20
N. Dak:	Minot	< 5	< 5	24	16	0	0	20	15
Ohio:	Cincinnati	< 5	< 5	10	10	0	0	15	15
	Cleveland	< 5	< 5	10	12	0	0	20	20
Okla:	Oklahoma City	< 5	< 5	9	11	0	10	10	10
Ore:	Portland	< 5	10	10	8	0	20	20	20
Penn:	Philadelphia	< 5	< 5	11	12	0	0	20	20
	Pittsburgh	< 5	NA	14	12	0	0	20	25
P.R.:	San Juan	5	5	6	4	0	0	15	20
R.I:	Providence	< 5	< 5	12	12	0	0	25	25
S.C:	Charleston	< 5	< 5	20	19	0	60	30	30
S. Dak:	Rapid City	< 5	< 5	16	11	0	0	15	25
Tenn:	Chattanooga	< 5	< 5	18	18	0	10	20	20
	Memphis	< 5	< 5	14	13	0	0	10	10
Tex:	Austin	< 5	< 5	4	5	0	40	5	10
	Dallas	< 5	< 5	10	8	0	30	10	10
Utah:	Salt Lake City	< 5	10	12	7	0	0	15	10
Vt:	Burlington	< 5	< 5	11	12	0	0	25	25
Va:	Norfolk	10	< 5	14	13	0	0	15	15
Wash:	Seattle	< 5	< 5	16	8	0	0	35	25
	Spokane	< 5	< 5	14	13	0	0	25	25
W. Va:	Charleston	5	< 5	15	14	0	0	10	15
Wisc:	Milwaukee	< 5	NA	9	9	0	0	15	20
Wyo:	Laramie	< 5	< 5	8	11	0	0	10	20
Network average		< 5	< 5	11.7	10.9	0	5	20	20

NA, no analysis.

Table 3. Iodine-131 concentrations, pCi/liter, in

Station location		January 1967														
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Ala:	Montgomery					< 10						114	72	73		
Alaska:	Palmer					< 10						< 10				
Ariz:	Phoenix						<10						<10			
Ark:	Little Rock			<10						21						
Calif:	Sacramento						22							23		
	San Francisco					15							21			
C.Z:	Cristobal			<10						<10						
Colo:	Denver					<10							<10			
Conn:	Hartford						<10							<10		
Del:	Wilmington					<10								<10		
D.C:	Washington						<10						<10			
Fla:	Tampa						<10							18		
Ga:	Atlanta				<10							113				
Hawaii:	Honolulu			<10							11					
Idaho:	Idaho Falls			<10						<10						
Ill:	Chicago			<10							17					
Ind:	Indianapolis			<10						<10						
Iowa:	Des Moines					11							<10			
Kans:	Wichita		<10							<10						
Ky:	Louisville			<10							20					
La:	New Orleans					<10							<10			
Maine:	Portland					<10						< 10				
Md:	Baltimore			<10								< 10				
Mass:	Boston			<10							<10					
Mich:	Detroit			18							10					
	Grand Rapids			<10						<10						
Minn:	Minneapolis			<10							<10					
Miss:	Jackson									36						
Mo:	Kansas City						11							32		
	St. Louis						<10							<10		
Mont:	Helena			<10							<10					
Nebr:	Omaha						<10						19			
Nev:	Las Vegas					<10							<10			
N.H:	Manchester			<10							<10					
N.J:	Trenton			<10							<10					
N. Mex:	Albuquerque			<10						<10						
N.Y:	Buffalo						<10							<10		
	New York			<10						<10						
	Syracuse				<10							19				
N.C:	Charlotte			<10						15						
N. Dak:	Minot			<10						<10						
Ohio:	Cincinnati			<10							<10					
	Cleveland						<10							<10		
Okla:	Oklahoma City				<10					23						
Ore:	Portland						74							17		
Pa:	Philadelphia						11							10		
	Pittsburgh			<10								17				
P.R:	San Juan									<10						
R.I:	Providence										<10					
S.C:	Charleston			<10							212					
S. Dak:	Rapid City			12						12						
Tenn:	Chattanooga					<10							39			
	Memphis				<10								27			
Tex:	Austin			<10			72							87		
	Dallas			<10						58						
Utah:	Salt Lake City			<10						27						<10
Vt:	Burlington			<10								< 10				
Va:	Norfolk						<10							16		
Wash:	Seattle			<10		<10							<10			
	Spokane		<10				<10				<10					
W. Va:	Charleston							<10							11	
Wisc:	Milwaukee						<10							<10		
Wyo:	Laramie				<10							< 10				

-70-

Pasteurized Milk Network samples, January 1967

January 1967—Continued																Station location	
16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31		
44	15	26								<10						Ala:	Montgomery.
		<10								<10						Alaska:	Palmer.
			11							<10						Ariz:	Phoenix.
15							<10							<10		Ark:	Little Rock.
				11											<10	Calif:	Sacramento.
			<10							<10							San Francisco.
<10							<10							<10		C.Z:	Cristobal.
			<10							<10						Colo:	Denver.
				<10							14					Conn:	Hartford.
			<10							17						Del:	Wilmington.
			<10							<10						D.C:	Washington.
			18						<10							Fla:	Tampa.
		23		21				17		<10					<10	Ga:	Altanta.
	11							<10							<10	Hawaii:	Honolulu.
<10							<10							<10		Idaho:	Idaho Falls.
	<10							<10								Ill:	Chicago.
	11						<10							<10		Ind:	Indianapolis.
	<10		<10		10			<10		<10		<10			<10	Iowa:	Des Moines.
<10							<10							<10		Kans:	Wichita.
	<10							<10							<10	Ky:	Louisville.
			28							10						La:	New Orleans.
<10							<10							14		Maine:	Portland.
	<10							<10							<10	Md:	Baltimore.
	<10							<10							13	Mass:	Boston.
	<10							12							11	Mich:	Detroit.
<10							11							<10			Grand Rapids.
	10							<10							<10	Minn:	Minneapolis.
42							20							<10		Miss:	Jackson.
				11							10					Mo:	Kansas City.
				<10							<10						St. Louis.
	<10							<10							<10	Mont:	Helena.
			<10								<10					Nebr:	Omaha.
	<10								<10							Nev:	Las Vegas.
	<10							<10							<10	N.H:	Manchester.
	<10							<10							10	N.J:	Trenton.
	<10							<10							<10	N. Mex:	Albuquerque.
				40							<10					N.Y:	Buffalo.
<10							<10							<10			New York.
		<10							<10								Syracuse.
12		<10		<10			10		<10		<10			<10		N.C:	Charlotte.
<10							<10							<10		N. Dak:	Minot.
	10						<10							10		Ohio:	Cincinnati.
				<10							<10						Cleveland.
		17					<10									Okla:	Oklahoma City.
				10							<10					Ore:	Portland.
				15							<10					Pa:	Philadelphia.
	<10							14									Pittsburgh.
<10							<10							<10		P.R:	San Juan.
	<10							<10							13	R.I:	Providence.
	18			21			<10		3		<10			<10		S.C:	Charleston.
<10							<10							<10		S. Dak:	Rapid City.
		15							<10							Tenn:	Chattanooga.
			11							<10							Memphis.
				19							<10					Tex:	Austin.
50							10							<10			Dallas.
							<10							<10		Utah:	Salt Lake City.
<10				<10				13			<10				10	Vt:	Burlington.
				<10							<10					Va:	Norfolk.
			<10							<10						Wash:	Seattle.
	<10							<10							10		Spokane.
					<10							<10				W. Va:	Charleston.
				<10							<10					Wisc:	Milwaukee.
		<10							10						<10	Wyo:	Laramie.

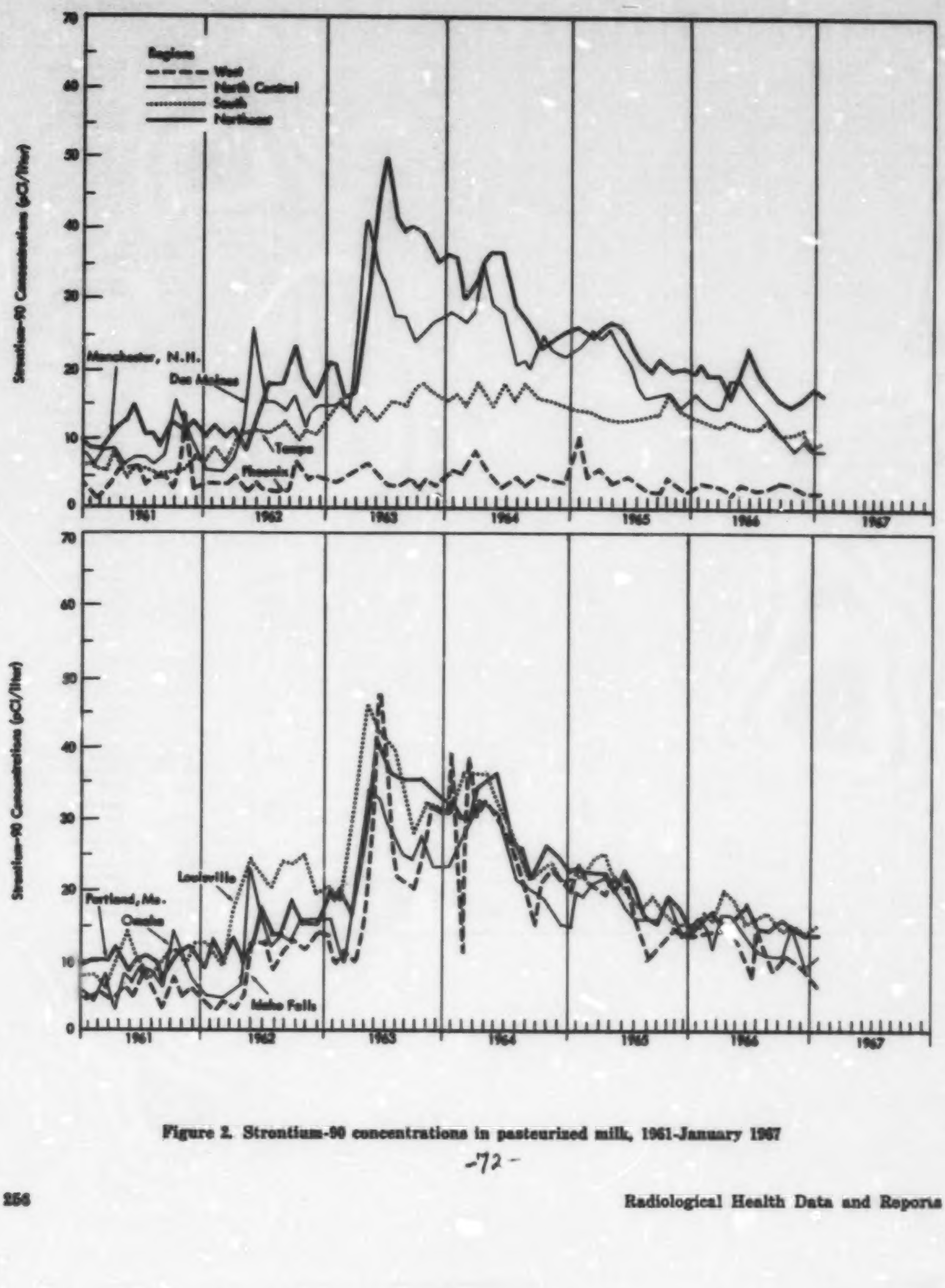


Figure 2. Strontium-90 concentrations in pasteurized milk, 1961-January 1967

-72-

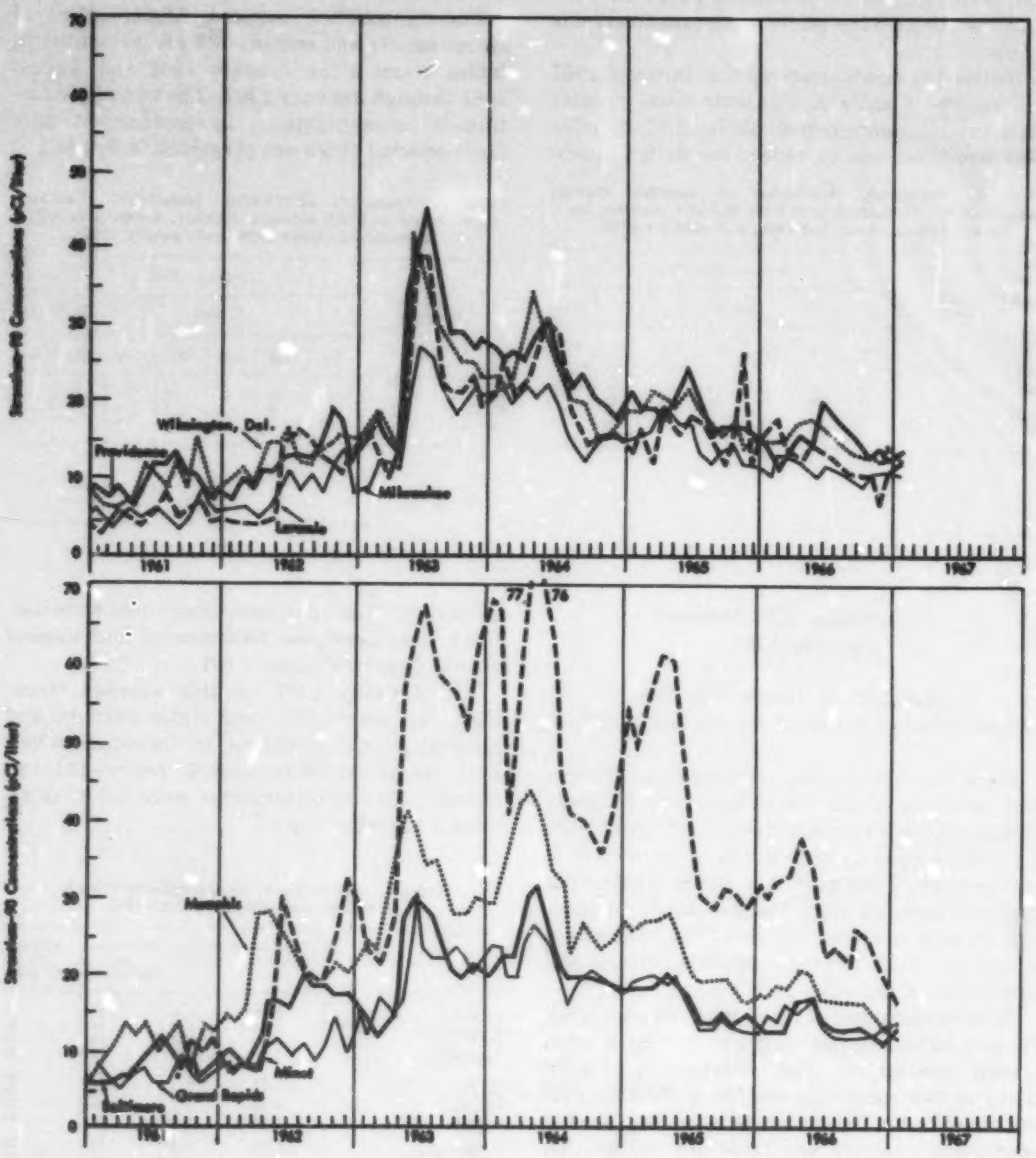


Figure 2. *Strontium-90 concentrations in pasteurized milk, 1961-January 1967—Continued*

mum detectable values; however, for iodine-131, zero was used for averaging purposes when concentrations were below minimum detectable levels.

Iodine-131 concentrations for January 1967 are shown in table 3. Concentrations greater than the minimum detectable level of 10 pCi/liter are presumed to reflect the fifth Chinese mainland atmospheric nuclear test of December 27, 1966, EST.

For comparative purposes, distributions of strontium-90 and cesium-137 are presented in tables 4 and 5 for January 1966 and August 1966 through January 1967. The average strontium-90 concentrations in pasteurized milk from selected cities are presented in figure 2.

Table 4. Frequency distribution of monthly average strontium-90 concentrations in milk at PMN stations, January, August-December 1966, and January 1967

Strontium-90 (pCi/liter)	Number of stations						
	1966						1967
	Jan	Aug	Sept	Oct	Nov	Dec	Jan
Under 10	10	15	21	18	19	23	24
10-19	46	40	37	39	40	35	36
20-29	6	7	5	6	4	5	3
30-39	1	1	0	0	0	0	0

Table 5. Frequency distribution, cesium-137 concentrations in milk at PMN stations, January, August of monthly average December 1966, and January 1967

Cesium-137 (pCi/liter)	Number of stations						
	1966						1967
	Jan	Aug	Sept	Oct	Nov	Dec	Jan
Under 50	60	56	61	62	61	62	62
50-99	2	6	1	0	2	1	1
100-149	1	1	1	1	0	0	0

---

2. Canadian Milk Network
January 1967 [1]

Radiation Protection Division
Department of National Health and Welfare

Since November 1955, the Radiation Protection Division of the Department of National Health and Welfare has been monitoring milk for radionuclide concentrations. Powdered milk was originally sampled, but liquid whole milk has been sampled since January 1963. At present, 16 milk sampling stations (figure 3) are in operation. Their locations coincide with air and precipitation sampling stations.

Milk samples are collected three times a week from selected dairies and are combined into weekly composites. The contribution of each dairy to the composite sample is directly proportional to the liquid volume of sales. Weekly spot-check analyses are made for iodine-131, and monthly composites are analyzed for strontium-90, cesium-137, and stable calcium and potassium. The analytical procedures were outlined in the December 1966 issue of *Radiological Health Data and Reports* (*2*).

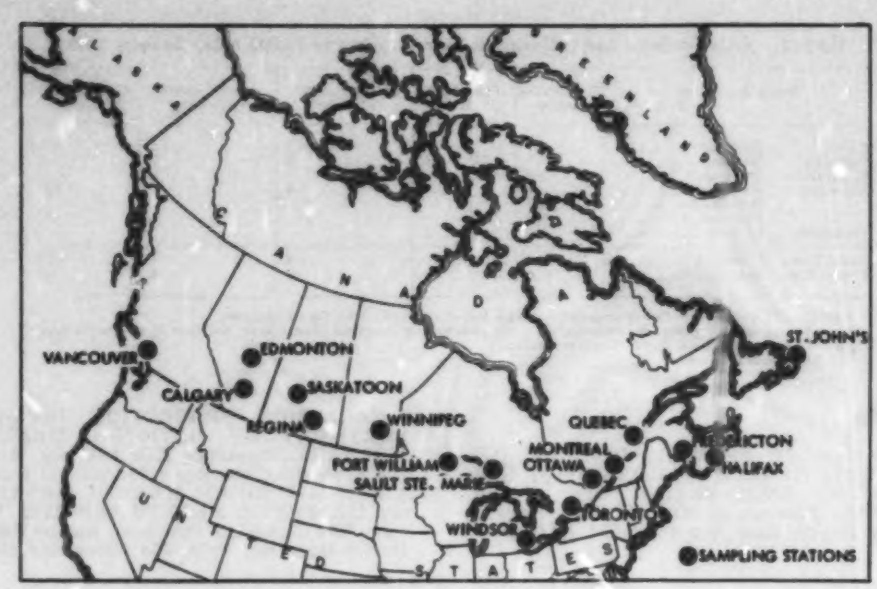
The January 1967 monthly average strontium-90, cesium-137, and stable calcium and potassium concentrations in Canadian whole milk are presented in table 6. Iodine-131 and strontium-89 concentrations were below minimum detectable levels.

Table 6. Stable elements and radionuclides in Canadian whole milk, January 1967

Station	Calcium (g/liter)	Potassium (g/liter)	Strontium-90 (pCi/liter)	Cesium-137 (pCi/liter)
Calgary	1.13	1.4	14	34
Edmonton	1.14	1.5	14	32
Ft. William	1.13	1.5	18	38
Fredericton	1.11	1.5	19	38
Halifax	1.11	1.5	17	40
Montreal	1.10	1.5	12	31
Ottawa	1.12	1.5	11	18
Quebec	1.08	1.6	18	44
Regina	1.02	1.4	10	20
St. John's, Nfld	1.12	1.5	21	59
Saskatoon	1.14	1.5	13	23
Sault Ste. Marie	1.12	1.5	18	35
Toronto	1.11	1.5	6	15
Vancouver	1.18	1.5	19	74
Windsor	1.14	1.5	6	19
Winnipeg	1.13	1.5	11	28
Average	1.12	1.5	14	34

---

[1] Prepared from February 1967 monthly report "Data from Radiation Protection Programs," Canadian Department of National Health and Welfare, Ottawa, Canada.



ALASKA
CANADA
GREENLAND
VANCOUVER
EDMONTON
CALGARY
SASKATOON
REGINA
WINNIPEG
PORT WILLIAM
SAULT STE. MARIE
QUEBEC
MONTREAL
OTTAWA
FREDERICTON
HALIFAX
ST. JOHN'S
TORONTO
WINDSOR
UNITED STATES
SAMPLING STATIONS

Figure 3. Canadian milk sampling stations

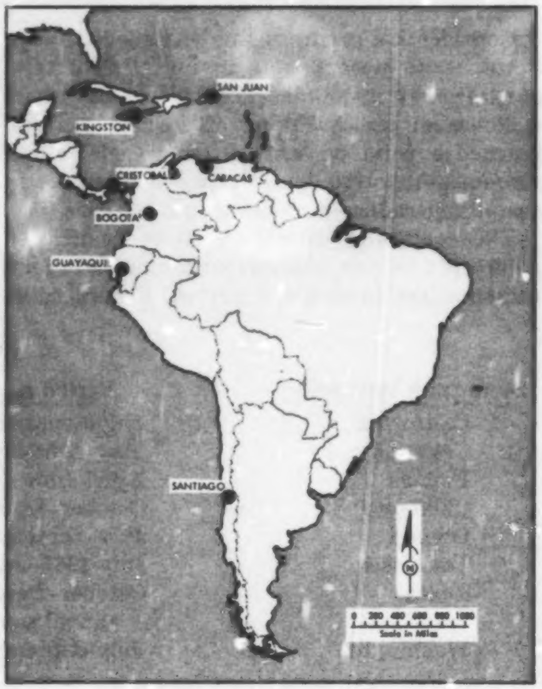
3. Pan American Milk Sampling Program January 1967

Pan American Health Organization and U.S. Public Health Service

The Pan American Health Organization (PAHO), in collaboration with the U.S. Public Health Service (PHS), furnishes assistance to health agencies in the American republics in developing national radiological health programs.

Under a joint agreement between agencies, air and milk sampling activities are conducted by a number of PAHO member countries (figure 4). Results of the milk sampling program are presented below. Further information on the sampling and analytical procedures employed was presented in the December 1966 issue of *Radiological Health Data and Reports* (*3*).

Table 7 presents stable potassium, strontium–89, strontium–90, and cesium–137 monthly average concentrations for January 1967.



SAN JUAN
KINGSTON
CRISTOBAL
CARACAS
BOGOTA
GUAYAQUIL
SANTIAGO
N
0 200 400 600 800 1000
Scale in Miles

Figure 4. Pan American Milk Sampling Program locations

-75-

Table 7. Stable element and radionuclide concentrations in PAHO milk,[a] January 1967

Sampling station		Number of samples	Potassium (g/liter)	Strontium-89 (pCi/liter)	Strontium-90 (pCi/liter)	Cesium-137 (pCi/liter)
Chile:	Santiago	4	1.7	<5	<1	<5
Colombia:	Bogotá	1	1.4	5	1	<5
Ecuador:	Guayaquil	NS				
Jamaica:	Kingston	1	1.4	5	9	105
	Mandeville	NS				
	Montego Bay	NS				
Venezuela:	Caracas	NS				
Canal Zone:	Cristóbal[b]	4	----------	<5	7	35
Puerto Rico:	San Juan[b]	4	----------	5	4	20

[a] Iodine-131 and barium-140 determinations were less than 10 pCi/liter for all samples.

[b] For comparison purposes, the radionuclide concentrations at Cristóbal, Canal Zone, and San Juan, Puerto Rico from the Pasteurized Milk Network are presented.

NS, no sample collected.

REFERENCES

(1) PUBLIC HEALTH SERVICE, DIVISION OF RADIOLOGICAL HEALTH and DIVISION OF ENVIRONMENTAL ENGINEERING AND FOOD PROTECTION. Pasteurized Milk Network, August 1966. Radiol Health Data Rep 7:698-701 (December 1966).

(2) RADIATION PROTECTION DIVISION, DEPARTMENT OF NATIONAL HEALTH AND WELFARE. Canadian Milk Network, August 1966. Radiol Health Data Rep 7:702-703 (December 1966).

(3) PAN AMERICAN HEALTH ORGANIZATION and U.S. PUBLIC HEALTH SERVICE. Pan American Milk Sampling Program, August 1966. Radiol Health Data Rep 7:704-705 (December 1966).

State Milk Surveillance Activities

Considerable progress has been made by the State health departments in initiating or expanding environmental surveillance activities in radiological health. Many of the States have reached a point of having comprehensive environmental surveillance programs and self-sustaining radiological health laboratories.

The continuing efforts of State health departments in the analysis and monitoring of radionuclides in milk complement Federal milk surveillance activities. State milk surveillance activities are continually undergoing developmental changes. The results presented herein are representative of current surveillance activities directed at the use of milk as an indicator of dietary intake of radioactivity.

In addition to the State milk networks presented herein, programs previously covered in *Radiological Health Data and Reports* include:

State milk network	Period covered	Last presented
California	July-September 1966	March 1967
Colorado	May 1965-June 1966	October 1966
Florida	April-June 1966	October 1966
Oklahoma	October–December 1966	April 1967
Oregon	July–September 1966	March 1967
Tennessee	July 1965–June 1966	April 1967
Texas	October–December and annual summary 1966	April 1967
Washington	July-September 1966	March 1967

1. Connecticut Milk Network
October–December 1966

Connecticut State Department of Health

The Connecticut State Department of Health has been monitoring pasteurized milk for strontium–89 and strontium–90 since April 1960. In May 1962, the program was expanded to include the determination of gamma-emitting radionuclides in milk.

The sampling program is flexible in nature, providing for sampling in five areas of the State (figure 1). At the present time, weekly samples representative of milk sold in the central area of the State are collected and analyzed for strontium-89, strontium-90, and gamma-ray emitters. Concentrations of iodine–131 are determined as an indication of the presence of radioactivity of recent origin.

Strontium–89 and strontium–90 are determined by chemical separation. Iodine–131 and other gamma-ray emitters are determined by gamma-ray scintillation spectroscopy.

The monthly average concentrations of strontium–89, strontium–90, iodine–131, and cesium–137 in Connecticut pasteurized milk are presented in table 1. These results are presented graphically in figure 2.

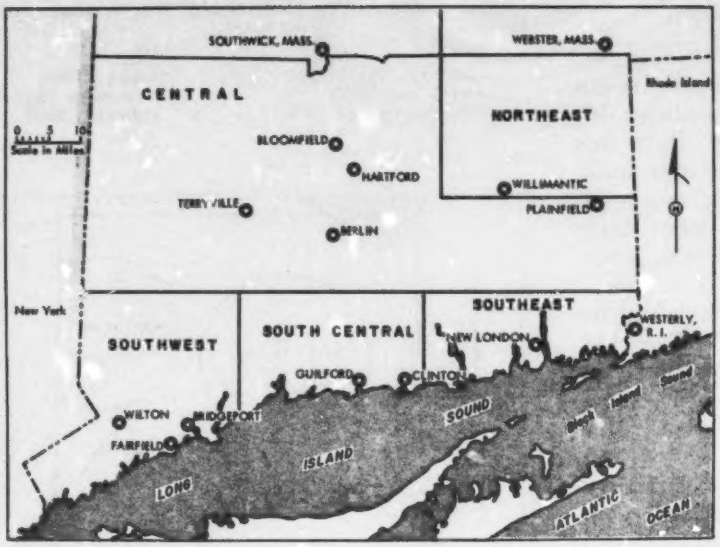

SOUTHWICK, MASS.
WEBSTER, MASS.
Rhode Island
CENTRAL
NORTHEAST
0 5 10
Scale in Miles
BLOOMFIELD
HARTFORD
WILLIMANTIC
PLAINFIELD
TERRYVILLE
BERLIN
New York
SOUTHWEST
SOUTH CENTRAL
SOUTHEAST
NEW LONDON
WESTERLY, R.I.
GUILFORD
CLINTON
WILTON
BRIDGEPORT
FAIRFIELD
LONG
ISLAND
SOUND
Block Island Sound
ATLANTIC
OCEAN

Figure 1. Connecticut pasteurized milk sampling areas

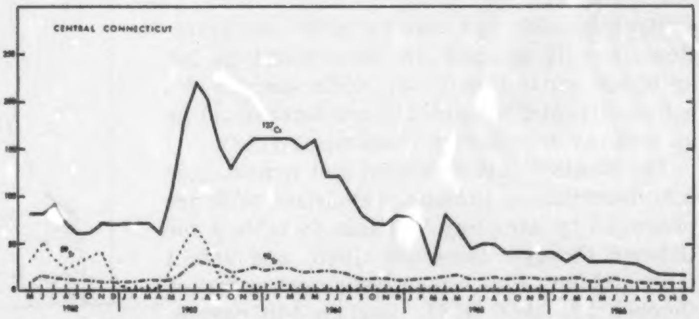


Figure 2. Radionuclide concentrations in central Connecticut pasteurized milk, May 1962-December 1966

Table 1. Radionuclide concentrations in central Connecticut milk, October–December 1966

Month 1966	Radionuclide concentrations (pCi/liter)			
	Strontium-89	Strontium-90	Iodine-131	Cesium-137
October	ND	9	<10	20
November	ND	9	<10	20
December	ND	9	<10	20

ND, below detectable levels.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
Annual summary 1965	May 1966
January–March 1966	August 1966
April–June 1966	November 1966
July–September 1966	February 1967

---

2. Indiana Milk Network October–December 1966

Bureau of Environmental Sanitation
Indiana State Board of Health

The Indiana State Board of Health began sampling pasteurized milk for radionuclide analysis in September 1961. The State was geographically divided into five major milksheds: northeast, northwest, central, southeast, and southwest (figure 3). One large dairy within each milkshed was assumed to be representative for sampling purposes.

The milk samples are analyzed monthly for strontium–89 and strontium–90. Iodine–131, cesium–137, and barium–140 are analyzed weekly for at least two of the milksheds. When iodine–131 concentrations exceed 100 pCi/liter, the sampling frequency is increased. From August 1963 to April 1966, because of the continued low concentrations of short-lived radionuclides, the sampling frequency was once a month for the northeast, southeast, and southwest milksheds.

Strontium–89 and strontium–90 concentrations in milk samples are determined by ion exchange separation (*1–2*) while cesium–137, iodine–131, and barium–140 are determined by gamma-ray scintillation spectrometry (*3*).

The monthly stable element and radionuclide concentrations in Indiana pasteurized milk are presented by sampling locations in table 2 for October through December 1966, and reflect the mainland China atmospheric nuclear test of October 27, 1966, EST. Barium–140 concentrations remained below detectable levels of 10 pCi/liter during this period.

The monthly network average concentrations of strontium–89, strontium–90, and cesium–137 are presented graphically in figure 4.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
January–March 1966	August 1966
April–June 1966	November 1966
July–September 1966	February 1967

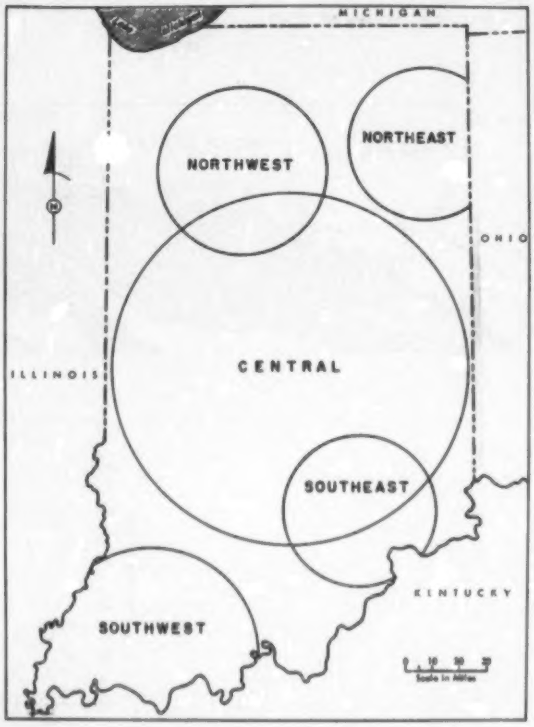


Figure 3. Indiana pasteurized milk sampling areas

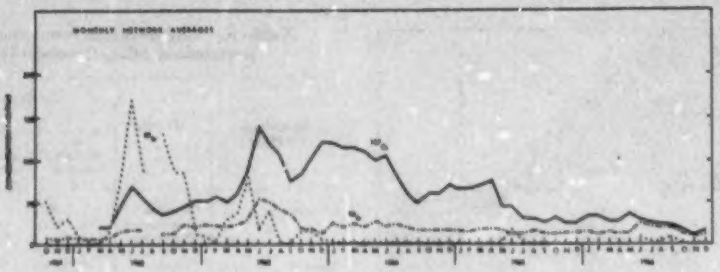


Figure 4. Radionuclide concentrations in Indiana pasteurized milk October 1961-December 1966

Table 2. Radionuclides in Indiana milk, October–December 1966

Sampling location	Calcium (g/liter)			Potassium-40 (pCi/liter)			Strontium-89 (pCi/liter)		
	October	November	December	October	November	December	October	November	December
Northeast	1.14	1.22	1.16	1,300	1,340	1,340	0	0	5
Southeast	1.10	1.30	1.16	1,320	....	1,350	0	0	0
Central	1.14	1.26	1.18	1,360	1,330	1,340	0	0	0
Southwest	1.14	1.24	1.18	1,310	1,270	1,270	0	0	0
Northwest	1.10	1.30	1.13	1,350	1,370	1,390	0	0	0
Average	1.12	1.26	1.16	1,330	1,330	1,340	0	0	0
	Strontium-90 (pCi/liter)			Iodine-131 (pCi/liter)			Cesium-137 (pCi/liter)		
Northeast	7	11	9	0	0	0	15	15	15
Southeast	12	8	12	0	....	0	15	....	20
Central	8	7	10	0	10	0	15	10	15
Southwest	12	12	13	0	10	0	10	10	10
Northwest	9	8	9	0	0	0	20	15	15
Average	10	9	11	0	0	0	15	10	15

---

3. Michigan Milk Network October–December 1966

Division of Occupational Health
Michigan Department of Health

The Michigan Department of Health began sampling pasteurized milk for radionuclide analyses in November 1962. Under this program, weekly pasteurized milk samples are collected in the seven major milk producing areas in the State: Charlevoix, Detroit, Grand Rapids, Lansing, Marquette, Monroe, and Saginaw (figure 5). Milkshed samples are composites from dairies in proportion to sales volume.

Strontium–90 concentrations are determined by an ion exchange method (4). Potassium–40, iodine–131, and cesium–137 concentrations are determined by gamma-ray scintillation spectrometry (4).

Table 3 presents the monthly average radionuclide concentrations in Michigan pasteurized milk. Strontium–90 and cesium–137 concentrations are presented graphically in figure 6 to show general trends.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
Annual summary 1965	May 1966
January–June 1966	November 1966
July–September 1966	February 1967

-79-

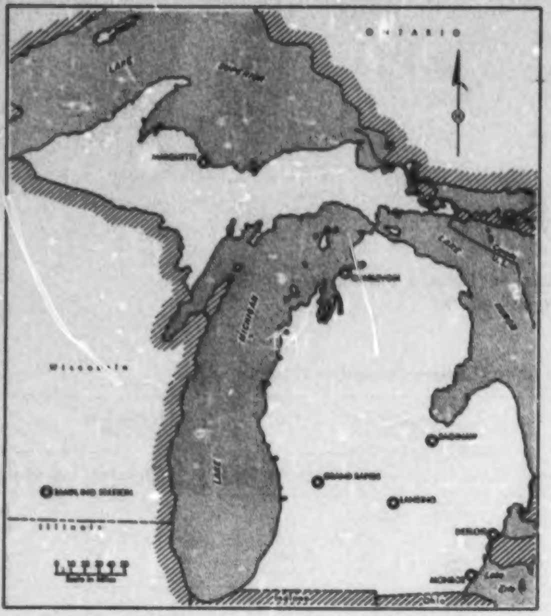

ONTARIO
LAKE SUPERIOR
MARQUETTE
CHARLEVOIX
LAKE MICHIGAN
LAKE HURON
Wisconsin
SAGINAW
GRAND RAPIDS
LANSING
DETROIT
MONROE
SAMPLING STATION
Illinois
Scale in Miles
Lake Erie
Ohio

Figure 5. Michigan pasteurized milk network sampling locations

Table 3. Radionuclide concentration in Michigan pasteurized milk, October–December 1966

Sampling location	Month	Radionuclide concentrations (pCi/liter)			
		Potassium-40	Strontium-90	Iodine-131	Cesium-137
Charlevoix	October	1,340	6	<14	17
	November	1,320	5	<14	20
	December	1,310	8	<14	16
Detroit	October	1,330	4	<14	14
	November	1,290	4	<14	11
	December	1,360	NA	<14	11
Grand Rapids	October	1,310	5	<14	17
	November	1,360	7	<14	16
	December	1,350	7	<14	13
Lansing	October	1,350	4	<14	13
	November	1,350	4	<14	12
	December	1,360	6	<14	14
Marquette	October	1,350	NA	<14	30
	November	1,370	NA	<14	30
	December	NA	NA	<14	NA
Monroe	October	1,350	4	<14	10
	November	1,330	3	<14	15
	December	1,300	5	<14	9
Saginaw	October	1,300	4	<14	13
	November	1,300	5	<14	15
	December	1,360	5	<14	14
Average	October	1,330	5	<14	16
	November	1,330	5	<14	17
	December	1,340	6	<14	13

NA, no analyses.

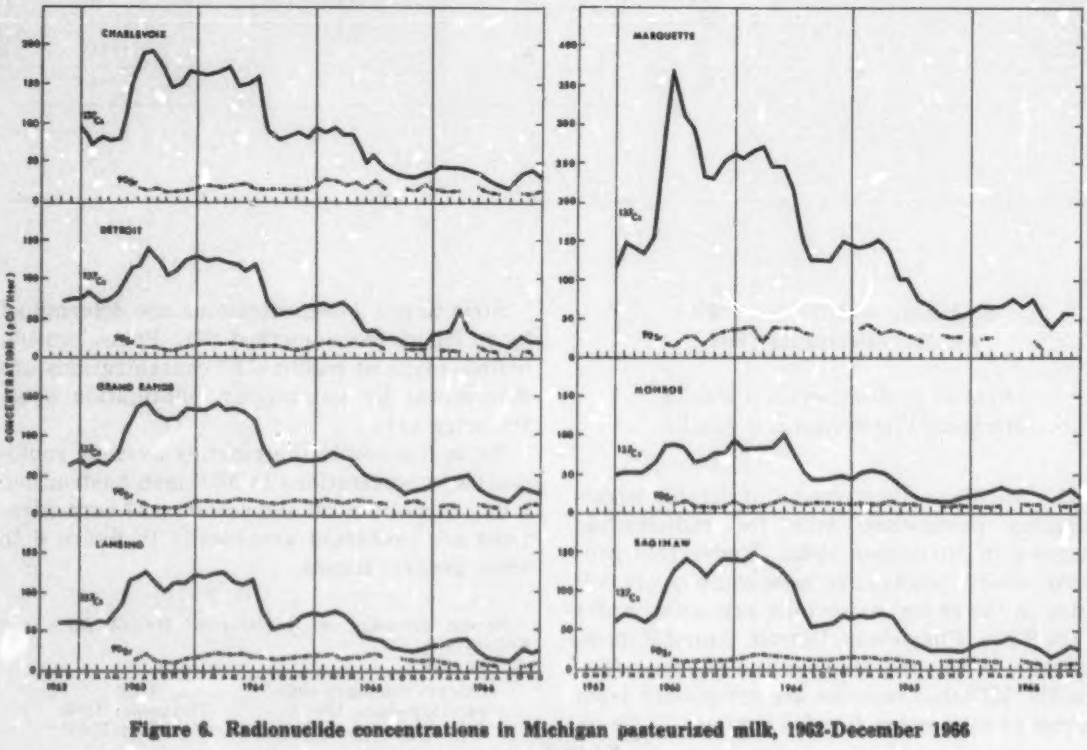


Figure 6. Radionuclide concentrations in Michigan pasteurized milk, 1962-December 1966

-80-

4. Minnesota Milk Network
October–December 1966

Division of Environmental Health
Minnesota Department of Health

In September 1958, the Minnesota Department of Health initiated a pasteurized milk network to monitor strontium-90 concentrations. Presently, monthly milk samples are collected from eight sampling locations in milksheds geographically the same as the Minnesota health districts (figure 7) and analyzed for strontium-90, iodine-131, and cesium-137 analyses. One-liter samples of processed Grade-A fluid milk are collected at bottling machines in pasteurization plants. The samples are customarily collected in the cities where the Minnesota Health Department district offices are located. However, it is sometimes convenient to collect at other locations. Such samples are considered representative of the district concerned.

Strontium-90 concentrations are determined radiochemically, while iodine-131 and cesium-137 concentrations are determined by gamma-ray scintillation spectrometry. The analytical procedures are presented in the semiannual report of the Minnesota Department of Health and the Rural Cooperative Power Association (*5*).

Strontium-90 and cesium-137 concentrations in milk are given for October through December 1966 in table 4, and are presented graphically by milkshed in figure 8 for the period 1962 through December 1966. Iodine-131 concentrations were less than 10 pCi/liter for the period October through December 1966.

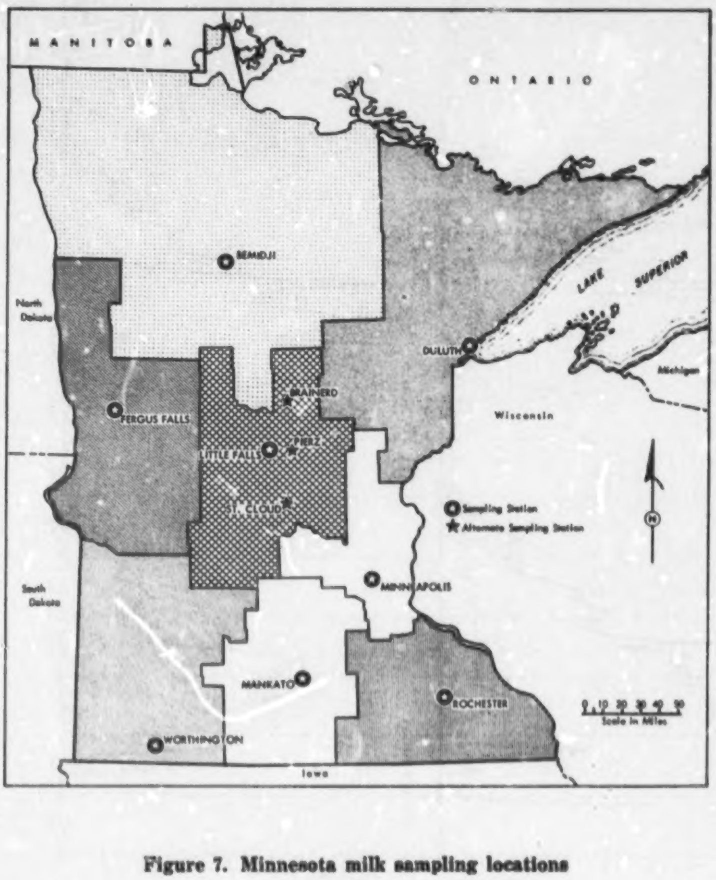

MANITOBA
ONTARIO
BEMIDJI
North Dakota
LAKE SUPERIOR
DULUTH
Michigan
Wisconsin
BRAINERD
FERGUS FALLS
PIERZ
LITTLE FALLS
ST. CLOUD
Sampling Station
Alternate Sampling Station
N
MINNEAPOLIS
South Dakota
MANKATO
ROCHESTER
WORTHINGTON
0 10 20 30 40 50
Scale in Miles
Iowa

Figure 7. Minnesota milk sampling locations

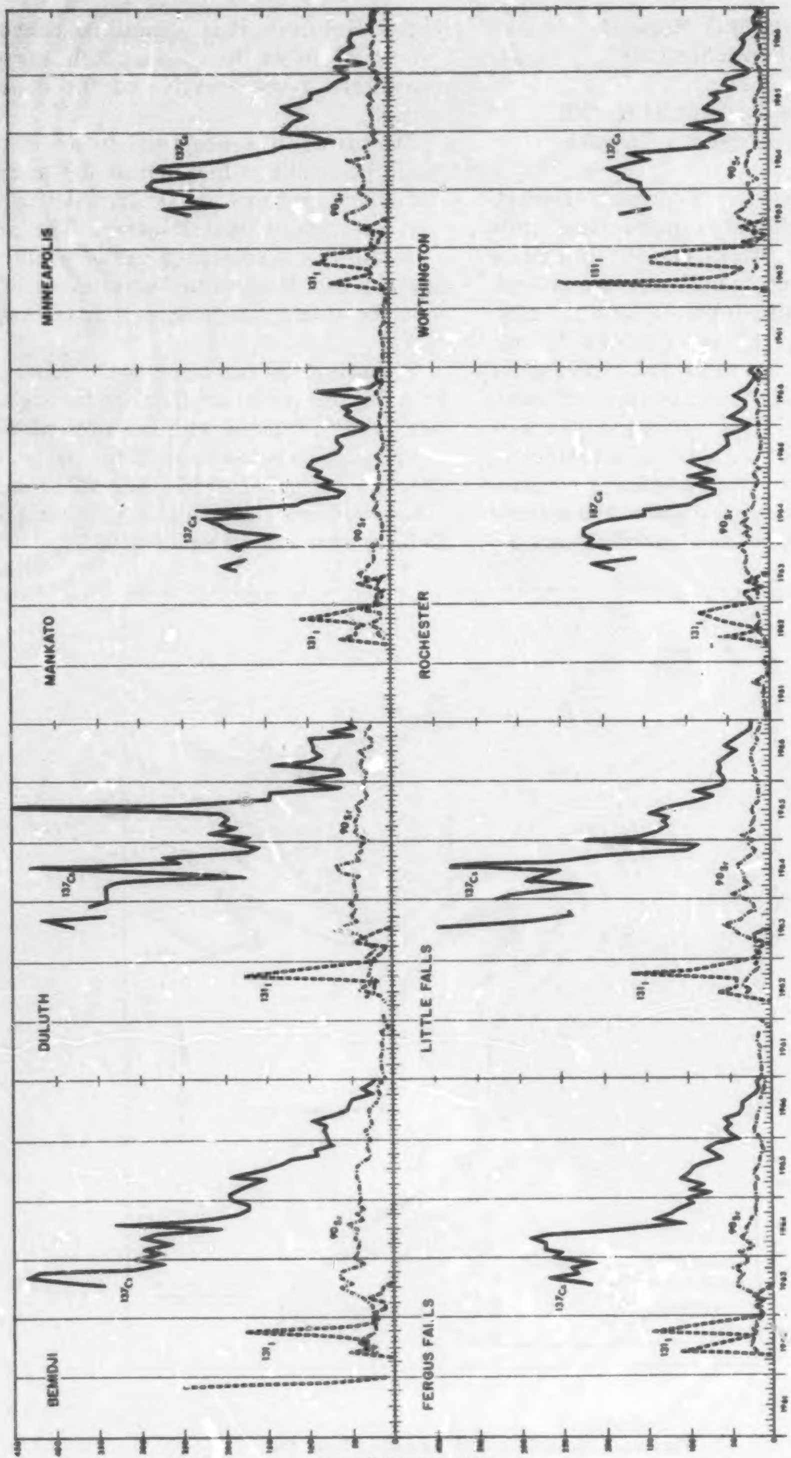


Figure 8. Radionuclide concentrations in Minnesota milk, 1961-December 1966

-82-

Table 4. Radionuclide concentrations in Minnesota milk, October–December 1966

Sampling location	Strontium-90 (pCi/liter)			Cesium-137 (pCi/liter)		
	Oct	Nov	Dec	Oct	Nov	Dec
Bemidji	18	14	18	37	28	25
Mankato	7	8	11	15	14	14
Rochester	9	11	12	15	20	16
Duluth	31	27	25	82	40	53
Worthington	8	8	6	14	9	15
Minneapolis	14	14	10	21	22	19
Fergus Falls	12	11	12	15	18	14
Little Falls	12	11	10	28	23	23
Average	14	13	13	28	22	22

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
Annual summary 1965	May 1966
January–March 1966	August 1966
April–June 1966	November 1966
July–September 1966	February 1967

---

5. New York Milk Network
October–December 1966

Division of Environmental Health Services
Department of Health, State of New York

Pasteurized milk samples collected routinely from six cities (figure 9) are analyzed for strontium–89, strontium–90, iodine–131, and barium-lanthanum–140 by the New York State Department of Health. At Buffalo, Newburgh, and Syracuse, milk samples are collected daily from processing plants, and composited weekly for radiochemical analyses. At Massena, samples are composited biweekly, while in New York City, a milk sample representing the total milk supply for 1 day is obtained and composited weekly for analysis. The Albany sample, taken at a marketing point, is analyzed daily for iodine–131 and other gamma-emitting radionuclides before being composited into a weekly sample. In the event that any sample contains iodine–131 concentrations exceeding 100 pCi/liter, increased surveillance is undertaken.

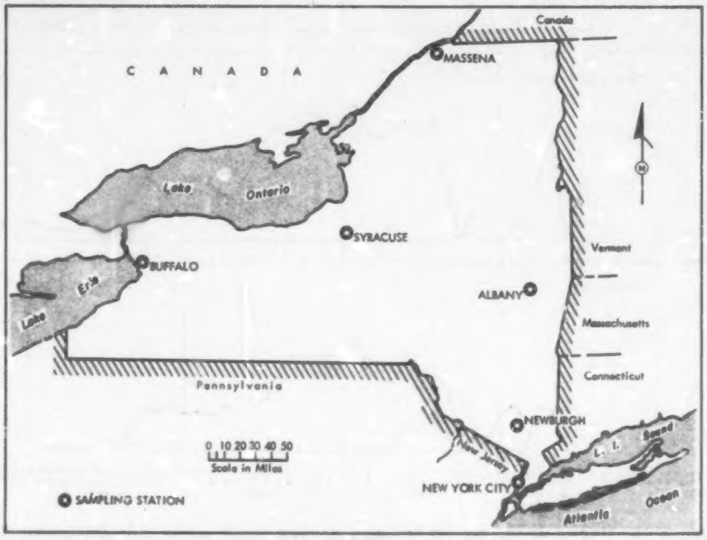

Canada
C A N A D A
MASSENA
Lake Ontario
SYRACUSE
BUFFALO
Lake Erie
Vermont
ALBANY
Massachusetts
Connecticut
Pennsylvania
NEWBURGH
New Jersey
NEW YORK CITY
L. I. Sound
Atlantic Ocean
0 10 20 30 40 50
Scale in Miles
SAMPLING STATION
N

Figure 9. New York milk sampling stations

-83-

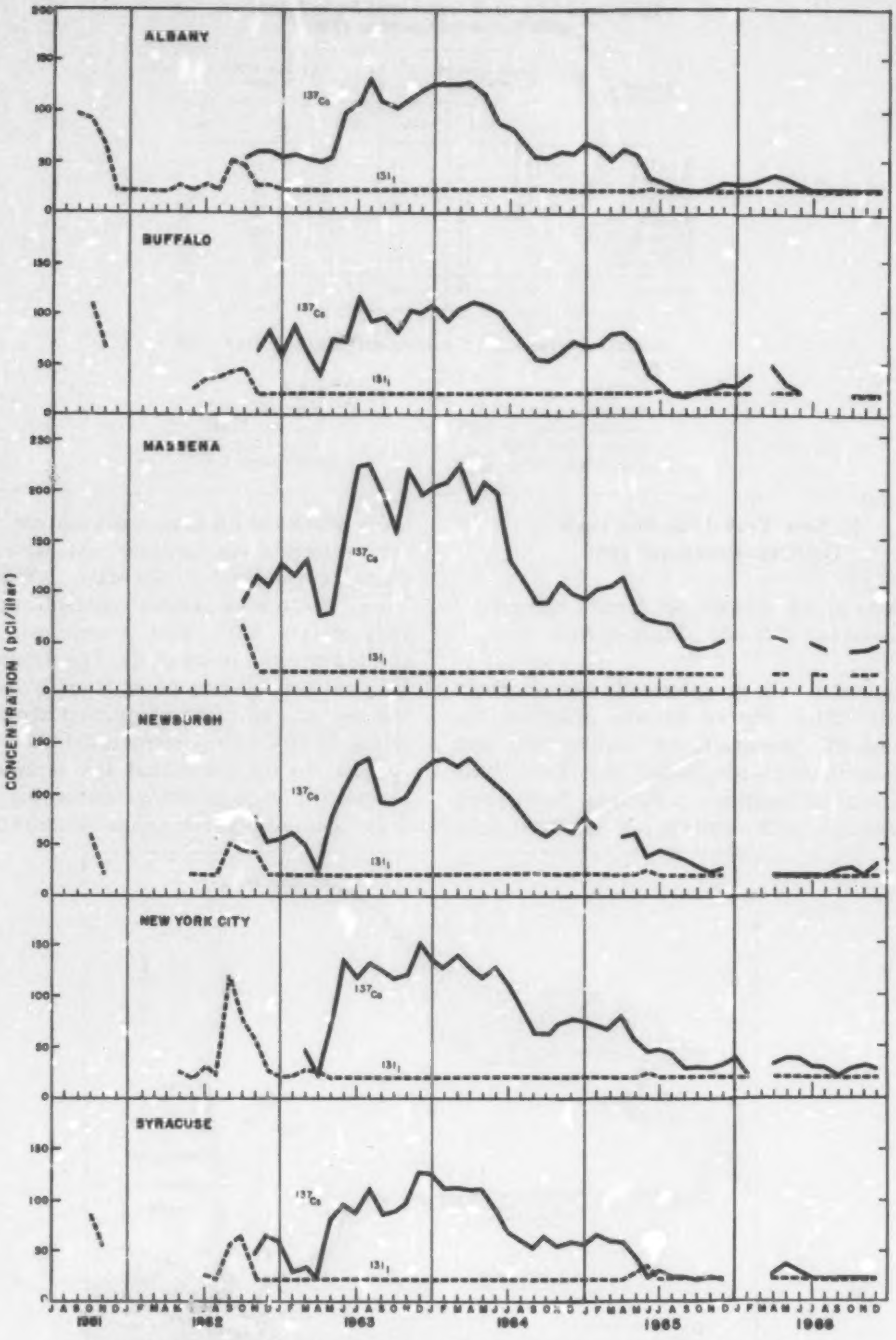


Figure 10. Radionuclide concentrations in New York milk, 1961-December 1966

-84-

Gamma-emitting radionuclides in milk are determined by scintillation spectrometry and the application of a matrix method of analysis (*6*) to the resultant spectral data.

The analytical procedure for determining strontium-89 and strontium-90 concentrations employs an ion exchange system similar to that developed by Porter and Kahn (*2*).

The monthly average radionuclide concentrations of strontium-89, strontium-90, iodine-131, and cesium-137 are shown in table 5 for October through December 1966. Cesium-137 and iodine-131 concentrations since September 1961 are presented graphically in figure 10.

Table 5. Radionuclide concentrations in New York milk,[a] October–December 1966

Sampling location	Cesium-137 (pCi/liter)			Strontium-90 (pCi/liter)		
	October	November	December	October	November	December
Albany	<20	<20	<20	7	7	7
Ashford	NS	--------	--------	NS	--------	--------
Bedford	NS	--------	--------	NS	--------	--------
Buffalo	<20	<20	<20	7	8	8
Clarktown	<20	NA	<20	9	NA	8
East Otto	NS	NS	NS	NS	NS	NS
Massena	43	43	45	10	11	11
Middleburg	22	23	25	12	11	10
Mount Pleasant	26	27	27	10	7	8
Newburgh	28	25	39	10	11	10
New York	31	32	31	16	14	15
Oyster Bay	53	52	48	10	9	11
Syracuse	<20	<20	<20	6	7	9
Yaphank	NS	--------	--------	NS	--------	--------
Yorkshire	NS	--------	--------	NS	--------	--------
Yorktown	36	31	41	18	18	19
Average	23	28	29	9	9	11

[a] For this period, strontium-89 and iodine-131 concentrations were below their minimum detectable levels of 3 pCi/liter and 20 pCi/liter, respectively.
NA, no analysis.
NS, no sample collected.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
Annual summary 1965	May 1966
January–June 1966	November 1966
July–September 1966	February 1967

---

6. Pennsylvania Milk Network
October–December 1966

Bureau of Environmental Health
Pennsylvania Department of Health

Samples of pasteurized milk are routinely collected from 10 major milk consumption areas throughout Pennsylvania (figure 11). Two samples per week are collected in Philadelphia and Pittsburgh, while weekly composite samples are collected from the other eight stations. At each sampling location subsamples are collected from the major dairies supplying the area and are composited in proportion to the amount of milk processed by each dairy. This composite is then sent to the Radiation Laboratory of the Division of Occupational Health, in Harrisburg, where the weekly sample are com-

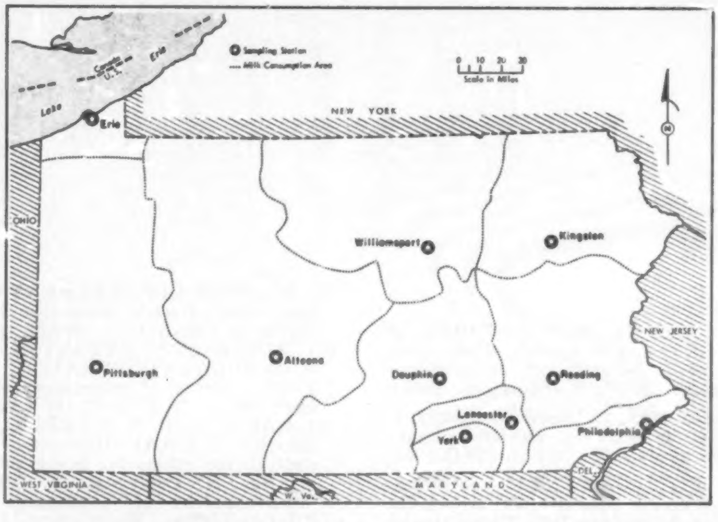


Figure 11. Pennsylvania pasteurized milk network sampling locations

bined for monthly analyses. Strontium–90 analyses have been carried out since April 1963.

The chemical separation technique for strontium–90 is essentially an ion exchange method described by Porter and Kahn (*2*).

The monthly average potassium–40, strontium–90, iodine–131, and cesium–137 concentrations in pasteurized milk are given in table 6 for October through December 1966. For comparative purposes, strontium–90, iodine–131, and cesium–137 concentrations are presented graphically in figure 12.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
Annual summary 1965	May 1966
January–March 1966	August 1966
April–June 1966	November 1966
July–September 1966	February 1967

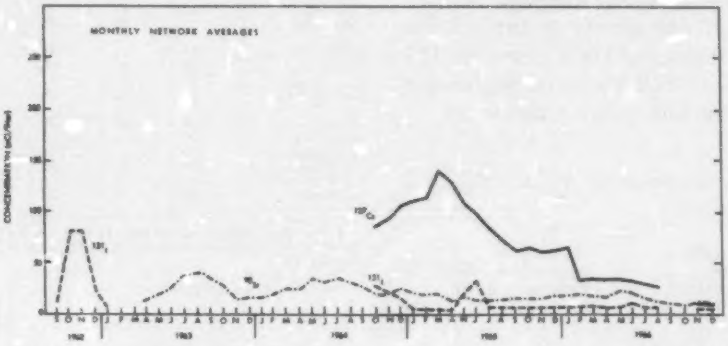


Figure 12. Radionuclide concentrations in Pennsylvania pasteurized milk, 1962-December 1966

Table 6. Radionuclide concentrations in Pennsylvania milk, October–December 1966

Sampling location	Radionuclide concentrations (pCi/liter)											
	Potassium-40			Strontium-90			Iodine-131			Cesium-137		
	Oct	Nov	Dec	Oct	Nov	Dec	Oct	Nov	Dec	Oct	Nov	Dec
Altoona	(a)	798	901	8	14	14	(a)	<10	<10	(a)	16	15
Dauphin	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Erie	(a)	814	853	9	15	11	(a)	<10	<10	(a)	15	12
Kingston	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Lancaster	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Philadelphia	(a)	NS	908	12	NS	9	(a)	<10	<10	(a)	NS	8
Pittsburgh	(a)	855	867	12	16	17	(a)	<10	<10	(a)	12	13
Reading	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Williamsport	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
York	(a)	853	881	10	13	8	(a)	<10	<10	(a)	14	12
Average	......	830	882	10	15	12	......	<10	<10	......	14	12

[a] Instrument out of order.
NS, no sample.

REFERENCES

(*1*) PORTER, C., D. CAHILL, R. SCHNEIDER, P. ROBBINS, W. PERRY, and B. KAHN. Determination of strontium–90 in milk by an ion-exchange method. Anal Chem 33:1306-1308 (September 1961).

(*2*) PORTER, C., and B. KAHN. Improved determination of strontium–90 in milk by an ion-exchange method. Anal Chem 36:676-678 (March 1964).

(*3*) BUREAU OF ENVIRONMENTAL SANITATION, INDIANA STATE BOARD OF HEALTH. Indiana milk network, April-June 1965. Radiol Health Data 6:612-614 (November 1965).

(*4*) MICHIGAN DEPARTMENT OF HEALTH. Michigan milk network, November 1962-December 1964. Radiol Health Data 6:487-492 (September 1965).

(*5*) MINNESOTA DEPARTMENT OF HEALTH AND RURAL COOPERATIVE POWER ASSOCIATION. Survey of environmental radioactivity, January-June 1965, COO-615-17 (August 1965).

(*6*) KAHN, B., G. K. MURPHY, C. PORTER, G. R. HAGEE, G. J. KARCHES, and A. S. GOLDIN. Rapid methods for estimating fission product concentrations in milk, PHS Publication No. 999-R-2 (March 1963). Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (March 1963).

Food and Diet Surveillance Activities

Efforts are being made by various Federal and State agencies to estimate the dietary intake of selected radionuclides on a continuous basis. These estimates, along with the guidance developed by the Federal Radiation Council, provide a basis for evaluating the significance of radioactivity in foods and diet.

Networks presently in operation and reported routinely include: (1) the Public Health Service's Institutional Total Diet Sampling Network, (2) the Atomic Energy Commission's Tri-City Diet Study, (3) the Food and Drug Administration's Teenage Diet Study, (4) the State of California's Diet Study, and (5) the State of Connecticut's Standard Diet Study. These networks provide data useful for developing estimates of nationwide dietary intakes of radionuclides. Periodically, results from the United Kingdom Diet Survey, conducted by the United Kingdom Agricultural Research Council Radiobiological Laboratory, are presented for comparison with data observed in the United States.

---

1. Estimated Daily Intake of Radionuclides in California Diets, May–August 1966

Bureau of Radiological Health
California State Department of Public Health

Since January 1964, the Bureau of Radiological Health, California State Department of Public Health, has made estimates of radionuclide levels in the diets of Californians (*1*).

Recognizing that a "standard" or "typical" diet does not exist, due to variations in individual tastes, an effort was made to select a diet which was reasonably representative of the food consumed in a given area. This objective was met by utilizing the "house" diet of a hospital in each of the 20 geographic areas of interest (figure 1).

Hospitals were chosen as the source of diet samples under the hypothesis that their diets are as "reasonably representative" as any other. General hospitals exist in each of the 20 selected geographic areas and operate with trained dietitians. There is good reason to believe that hospitals utilize foods which are marketed in their respective communities. Also, working relations for entry into hospitals existed through the State Bureau of Nutrition and Hospitals.

Sampling procedure

In general, the sampling procedure is the same at each hospital. Samples are collected every 2 months at each facility. Each sample represents the edible portion of a regular meal (the standard diet) for a full 7-day week (21 consecutive meals).

After each sample is collected, it is suitably preserved and shipped to the Sanitation and Radiation Laboratory of the State Department of Public Health. Accompanying each sample is a record prepared by the dietitians indicating the types and quantities of food included.

Analytical procedures

After weighing at the laboratory, each sample is homogenized and analyzed for gamma-ray emitters, then dried and ashed prior to analysis for strontium-89, strontium-90, radium-226, and stable calcium, strontium, and sodium.

Data and discussion

The resultant estimates of daily intake of radionuclides in the California diets are given in table 1 (May–June 1966) and table 2 (July–August 1966).

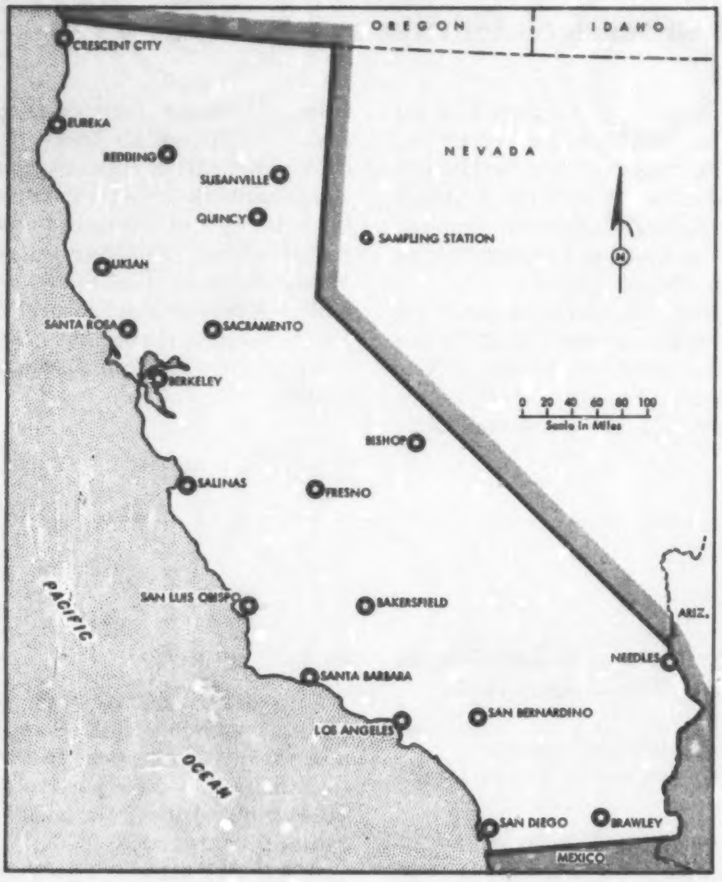

OREGON
IDAHO
NEVADA
CRESCENT CITY
EUREKA
REDDING
SUSANVILLE
QUINCY
SAMPLING STATION
N
UKIAH
SANTA ROSA
SACRAMENTO
BERKELEY
0 20 40 60 80 100
Scale in Miles
BISHOP
SALINAS
FRESNO
PACIFIC
SAN LUIS OBISPO
BAKERSFIELD
ARIZ.
NEEDLES
SANTA BARBARA
SAN BERNARDINO
LOS ANGELES
OCEAN
SAN DIEGO
BRAWLEY
MEXICO

Figure 1. California diet sampling stations

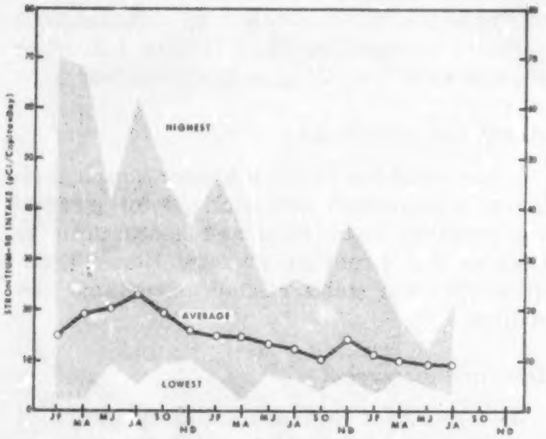


Figure 2. Averages and ranges of daily strontium-90 intake in California diets, 1964-August 1966

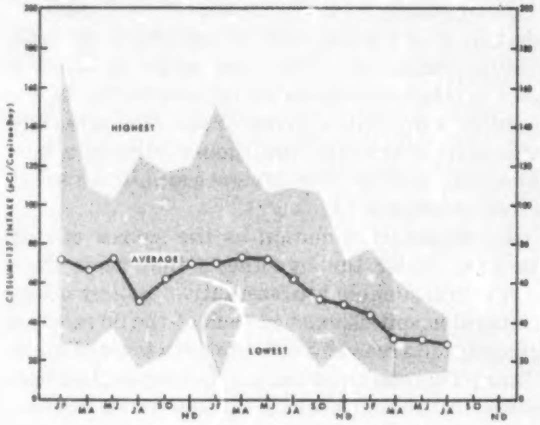


Figure 3. Averages and ranges of daily cesium-137 intake in California diets, 1964-August 1966

-88-

Table 1. Estimated daily intake of radionuclides in California diets, May–June 1966 [a]

City	Consumption (kg/capita-day [b])	Intake [c] (pCi/capita-day)				Intake (g/capita-day)			
		Strontium-90	Zirconium-95	Cesium-137	Radium-226	Potassium [d]	Sodium	Calcium	Stable strontium
Bakersfield	2.2	9	3	13	0.8	2.9	4.2	1.3	0.002
Berkeley	2.3	8	0	32	.7	2.0	3.2	1.0	.002
Bishop	2.2	8	0	44	.8	2.5	4.1	.6	.002
Brawley	2.0	10	0	22	1.7	2.9	4.5	.9	.005
Crescent City	2.1	13	2	32	.5	2.4	4.3	.8	.002
Eureka	2.2	12	0	38	.8	2.9	4.2	1.2	.004
Fresno	2.6	9	0	49	.8	2.7	4.9	.7	.002
Los Angeles	1.9	9	0	28	1.2	2.7	3.6	.8	.002
Needles	2.5	8	0	27	1.2	2.9	3.7	1.2	.003
Quincy	1.4	5	0	30	.3	1.8	2.7	.5	.001
Redding	2.4	12	0	37	1.3	2.7	4.3	1.4	.003
Sacramento	2.7	12	0	41	1.5	2.9	6.5	1.2	.003
Salinas	2.5	8	5	36	1.0	3.0	5.0	.9	.002
San Bernardino	1.9	7	0	26	1.8	2.7	3.7	.8	.003
San Diego	2.0	7	0	32	1.6	2.6	2.7	.8	.002
San Luis Obispo	1.4	7	1	24	.5	NA	NA	.9	NA
Santa Barbara	2.2	9	0	30	.5	3.0	4.0	1.1	.003
Santa Rosa	2.2	10	0	29	.8	2.3	3.1	1.1	.001
Susanville	1.7	7	1	26	.7	2.0	3.5	.7	.002
Ukiah	2.5	17	3	40	.6	2.8	3.9	1.6	.003

[a] Based on analyses of Hospital Standard Diets located in listed cities. Strontium-89 not detectable.
[b] Kilograms of food per person per day in the diet.
[c] Manganese-54, cerium-141, and cerium-144 concentrations were non-detectable for this period.
[d] Natural potassium contains 0.0119 percent radioactive potassium-40.

Table 2. Estimated daily intake of radionuclides in California diets, July–August 1966 [a]

City	Consumption (kg/capita-day [b])	Intake [c] (pCi/capita-day)				Intake (g/capita-day)			
		Strontium-90	Zirconium-95	Cesium-137	Radium-226	Potassium [d]	Sodium	Calcium	Stable strontium
Bakersfield	2.3	6	0	23	0.7	2.7	4.0	1.1	0.002
Berkeley	2.6	10	1	36	1.1	2.6	3.1	1.0	.002
Bishop	2.1	6	3	32	.4	2.1	4.0	.8	.002
Brawley	1.5	3	4	18	.6	1.1	1.8	.6	.001
Crescent City	1.6	8	0	37	.4	1.8	3.4	.6	.001
Eureka	2.1	11	1	29	.6	2.2	3.9	1.0	.003
Fresno	2.1	21	0	31	2.1	3.4	7.1	1.6	.004
Los Angeles	2.4	7	0	27	1.3	2.7	3.7	.9	.002
Needles	1.8	9	0	22	.9	2.0	2.7	1.0	.003
Quincy	1.8	10	0	30	.9	2.8	7.7	.8	.003
Redding	1.9	10	0	28	.7	2.0	7.5	1.8	.003
Sacramento	2.7	13	0	42	1.4	2.7	5.1	2.9	.003
Salinas	2.4	10	0	34	.9	2.7	5.2	.8	.002
San Bernardino	1.7	6	0	15	.5	2.0	3.1	.6	.002
San Diego	2.1	6	0	32	.9	2.6	2.8	.7	.003
San Luis Obispo	1.4	4	0	29	1.0	1.8	3.0	.7	.001
Santa Barbara	2.1	8	0	24	.4	2.7	3.4	1.0	.002
Santa Rosa	2.3	8	3	29	.8	1.8	4.0	1.0	.002
Susanville	1.9	7	5	20	.2	2.0	3.9	.8	.002
Ukiah	2.7	8	1	29	.5	2.7	3.8	1.6	.002

[a] Based on analyses of Hospital Standard Diets located in listed cities. Strontium-89 not detectable.
[b] Kilograms of food per person per day in the diet.
[c] Manganese-54, cerium-141, and cerium-144 concentrations were non-detectable for this period.
[d] Natural potassium contains 0.0119 percent radioactive potassium-40.

It should be noted that levels of radioactivity were observed to be far below those levels for which consideration should be given to protective health action. Stontium–90 intake in the California diet for the May–June 1966 period varied from 5 to 12 pCi/capita-day with an average of 9 pCi/capita-day. Cesium–137 intake varied from 13 to 49 pCi/capita-day with an average of 31 pCi/capita-day. For the July–August 1966 sampling period the strontium–90 intake varied from 3 to 21 pCi/capita-day with an average of 9 pCi/capita-day. Cesium-137 intake varied from 15 to 42 pCi/capita-day with an average of 28 pCi/capita-day. A summary of strontium-90 and cesium-137 intake trends in California diets from January 1964 through August 1966 is given in figures 2 and 3.

REFERENCES

(1) STATE OF CALIFORNIA DEPARTMENT OF PUBLIC HEALTH, BUREAU OF RADIOLOGICAL HEALTH. Radiol Health News 3:3 (July 1964). 2151 Berkeley Way, Berkeley, Calif. 94704.

(2) CONNECTICUT STATE DEPARTMENT OF HEALTH. Estimated daily intake of radionuclides in Connecticut standard diet, March 1963-December 1964. Radiol Health Data 6:381-382 (July 1965).

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
January–April 1965	March 1966
May–August 1965	June 1966
September–December 1965	September 1966
January–April 1966	January 1967

---

2. Estimated Daily Intake of Radionuclides in Connecticut Standard Diet, July–December 1966

Connecticut State Department of Health

The Connecticut State Department of Health has been analyzing a standard diet on a monthly basis since March 1963. Analyses are made for strontium-89, strontium-90, and gamma-ray emitters.

The standard diet was selected to represent the food intake of an 18-year-old boy for 1 day (table 3). The total weight of the complete blended diet, averaging 3 kilograms, includes milk and dairy products. When raw fruit or vegetables were sampled, they were washed before blending.

Cesium-137 concentrations were determined by gamma-ray spectrometry (*1*). Strontium-89 and strontium-90 concentrations were determined by chemical separation techniques (*2*).

Table 3. Foods included in standard diet

Bread, white—8 slices
Butter—½ stick
Carrots, scraped—½ cup
Celery, washed and trimmed—3 stalks
Cookies—4
Cottage cheese—⅔ cup
Cupcakes—2
Egg—1
Green beans, washed—½ cup
Ham—85 grams
Hamburger—227 grams
Ice cream—½ pint
Lettuce, washed—4-5 leaves
Milk—3 cups
Oatmeal—uncooked—43 grams
Orange—1
Peanut butter—2½ tablespoons
Pears, canned—2 halves with juice
Potatoes, washed, not peeled—2
Sugar—5 tablespoons
Tomato juice—113 grams
Tuna fish, drained—43 grams

Table 4. Radionuclide concentrations in Connecticut standard diet, July–December 1966[a]

Month 1966	Potassium (g/kg)	Strontium-90 (pCi/kg)	Cesium-137 (pCi/kg)
July	2.1	10	30
August	2.1	9	30
September	2.3	9	30
October	2.3	13	10
November	2.3	9	30
December	2.4	11	30

[a] All strontium-89 values were <3 pCi/kg for this period.

Table 4 presents the analytical results for the Connecticut standard diet from July through December 1966. Results representative of the total daily intake for the radionuclides observed are presented in table 5.

Table 5. Daily radionuclide intakes in Connecticut standard diet, July–December 1966[a]

Month 1966	Potassium (g/day)	Strontium-90 (pCi/day)	Cesium-137 (pCi/day)
July	6.1	28	90
August	6.3	26	80
September	6.5	27	80
October	7.4	43	40
November	6.8	27	100
December	7.1	32	90

[a] All strontium-89 values were <3 pCi/kg for this period.

In order to evaluate general trends, the strontium–90 and cesium–137 daily intakes are plotted as a function of time in figures 4 and 5.

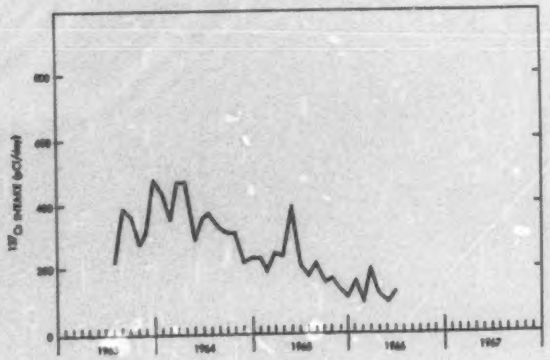


Figure 4. Cesium-137 intake in Connecticut standard diet, 1963-December 1966

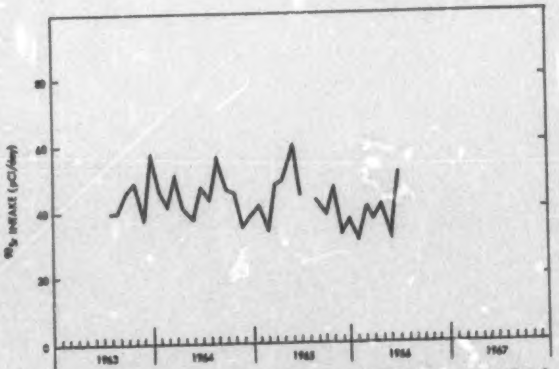


Figure 5. Strontium-90 intake in Connecticut standard diet, 1963-December 1966

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
March 1963–December 1964	July 1965
January–June 1965	February 1966
July 1965–June 1966	November 1966

SECTION II. WATER

The Public Health Service, the Federal Water Pollution Control Administration, and other Federal, State, and local agencies operate extensive water quality sampling and analysis programs for surface, ground, and treated water. Most of these programs include determinations of gross beta and gross alpha radioactivity and specific radionuclides.

Although the determination of the total radionuclide intake from all sources is of primary importance, a measure of the public health importance of radioactivity levels in water can be obtained by comparison of the observed values with the Public Health Service Drinking Water Standards (*1*). These Standards, based on consideration of Federal Radiation Council (FRC) recommendations (*2–4*), set the limits for approval of a drinking water supply containing radium-226 and strontium-90 as 3 pCi/liter, and 10 pCi/liter, respectively. Limits may be higher if total intake of radioactivity from all sources indicates that such intakes are within the guides recommended by FRC for control action. In the known absence [1] of strontium-90 and alpha-particle emitters, the limit is 1,000 pCi/liter gross beta radioactivity, except when more complete analysis indicates that concentrations of radionuclides are not likely to cause exposures greater than the safe limits indicated by the Radiation Protection Guides. Surveillance data from a number of Federal and State programs are published periodically to show current and long-range trends. Water programs previously reported in *Radiological Health Data and Reports* are listed below.

Program	Period reported	Last presented
California Water Sampling Program	July–December 1965	November 1966
Coast Guard Water Sampling Program	1965	November 1966
Colorado River Basin Sampling Network	1962–1964	November 1965
Drinking Water Analysis Program	1962	October 1965
Florida Water Sampling Program	1964	November 1965
Kentucky Water Sampling Program	May 1963–June 1964	March 1965
Lower Columbia River Radiological Survey in Oregon	August 1963–July 1964	October 1965
Minnesota Surface Water Sampling Program	January–June 1966	January 1967
New York Surface Water Sampling Program	June–December 1965	June 1966
North Carolina Water Sampling Program	1964	November 1965
Radiostrontium in Tap Water, HASL	November 1965–June 1966	December 1966
Washington Surface Water Sampling Program	July 1964–June 1965	May 1966

---

[1] Absence is taken to mean a negligibly small fraction of the specific limits of 3 pCi/liter and 10 pCi/liter for unidentified alpha-particle emitters and strontium-90, respectively.

REFERENCES

(*1*) U.S. PUBLIC HEALTH SERVICE. Drinking water standards, revised 1962, PHS Publication No. 956. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (March 1963).

(*2*) FEDERAL RADIATION COUNCIL. Radiation Protection Guidance for Federal Agencies. Memorandum for the President, September 1961. Reprint from the Federal Register of September 26, 1961.

(*3*) FEDERAL RADIATION COUNCIL. Background material for the development of Radiation Protection Standards, Report No. 1. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (May 1960).

(*4*) FEDERAL RADIATION COUNCIL. Background material for the development of Radiation Protection Standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (September 1961).

Gross Radioactivity in Surface Waters of the United States, November 1966

Division of Pollution Surveillance
Federal Water Pollution Control Administration
Department of Interior

The monitoring of levels of radioactivity in surface waters of the United States was begun in 1957 as part of the Federal Water Pollution Control Administration's Water Pollution Surveillance System. Table 1 presents the current preliminary results of the alpha- and beta-particle analysis. The radioactivity associated with dissolved solids provides a rough indication of the levels which would occur in treated water, since nearly all suspended matter is removed by treatment processes. Strontium-90 results are reported semiannually. The stations on each river are arranged in the table according to their distance from the headwaters. Figure 1 indicates the average total beta radioactivity in suspended-plus-dissolved solids in raw water collected at each station. A description of the sampling and analytical procedures was published in the June 1966 issue of *Radiological Health Data and Reports.*

Complete data and exact sampling locations for 1958 through 1963 are published in annual compilations (*1–6*). Detailed data for subsequent years are available on request.

Special note is taken when the alpha radioactivity is 15 pCi/liter or greater or when the beta radioactivity is 150 pCi/liter or greater. These arbitrary levels provide a basis for the selection of certain data and for comment on the data, if needed. They reflect no public health

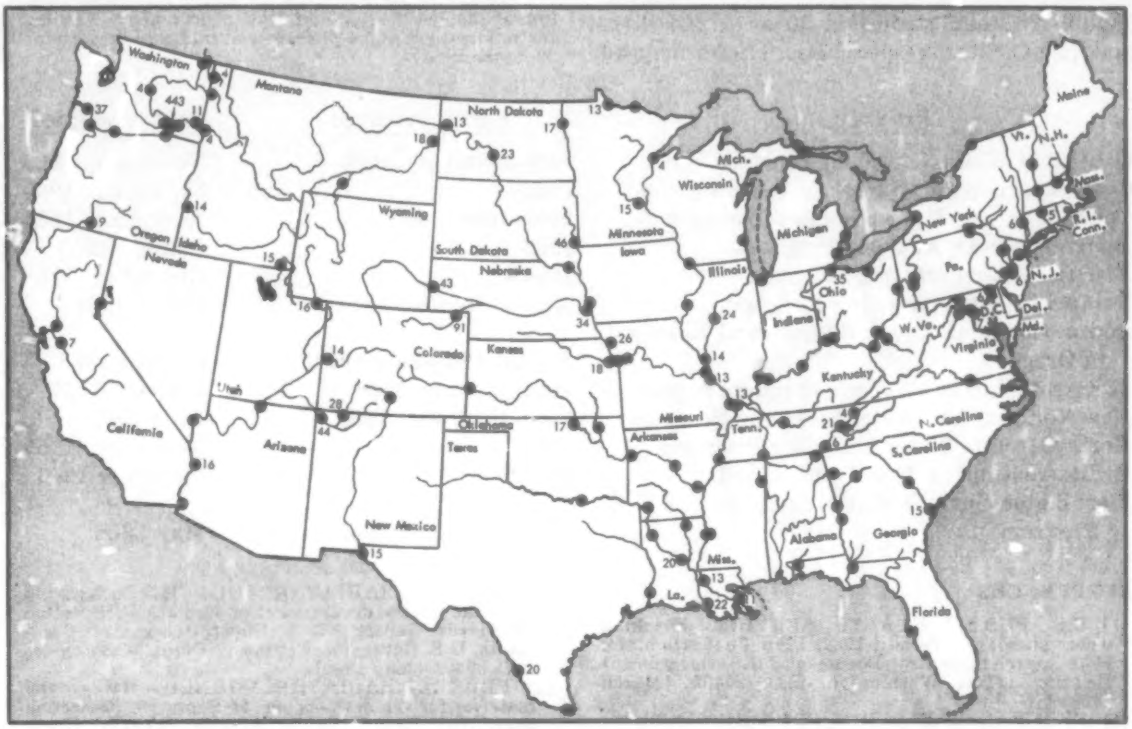

Washington
Montana
North Dakota
Maine
Vt.
N.H.
Mass.
R.I.
Conn.
Mich.
Wisconsin
Minnesota
Michigan
New York
Oregon
Idaho
Wyoming
South Dakota
Nebraska
Iowa
Illinois
Ohio
Pa.
N.J.
Nevada
Indiana
D.C.
Del.
Md.
W. Va.
Virginia
Colorado
Kansas
Missouri
Kentucky
Utah
California
Arizona
Oklahoma
Texas
Arkansas
Tenn.
N. Carolina
S. Carolina
New Mexico
Miss.
Alabama
Georgia
La.
Florida
37
4
443
11
4
18
13
17
23
13
4
14
9
15
46
15
43
16
91
34
26
18
24
14
13
13
35
6
51
6
4
7
7
14
28
44
16
17
21
4
15
20
13
22
15
20

Figure 1. Sampling locations and associated total beta radioactivity (pCi/liter) in surface waters, November 1966

significance, as the Public Health Service drinking water standards have already provided the basis for this assessment. Changes from or toward these arbitrary levels are also noted in terms of changes in radioactivity per unit weight of solids. No discussion of gross radioactivity per gram of dissolved or suspended solids for all stations of the Water Pollution Surveillance System will be attempted at this time. Comments are made only on monthly average values. Occasional high values from single weekly samples may be absorbed into a relatively low average. When these values are significantly high, comment will be made.

During both October and November, the following stations showed alpha radioactivity in excess of 15 pCi/liter on either dissolved or suspended solids:

South Platte River; Julesburg, Colo.
North Platte River; Henry, Nebr.

During November the following stations declined in alpha radioactivity from the previous month to less than 15 pCi/liter on either dissolved or suspended solids:

Rio Grande; Laredo, Tex.
San Juan River; Shiprock, New Mex.
Colorado River; Loma, Colo.
Arkansas River; Coolidge, Kans.

On the Columbia River at Pasco, Wash., the beta radioactivity on dissolved solids showed an average of well over 150 pCi/liter.

Table 1. Radioactivity in raw surface waters, November 1966

Station	Average beta radioactivity (pCi/liter)			Average alpha radioactivity (pCi/liter)		
	Suspended	Dissolved	Total	Suspended	Dissolved	Total
Animas River:						
Cedar Hill, N. Mex.	1	27	28	0	2	2
Arkansas River:						
Ponca City, Okla.	1	16	17	0	2	2
Atchafalaya River:						
Morgan City, La.	13	9	22	4	1	5
Bear River:						
Preston, Idaho	0	15	15	0	3	3
Big Sioux River:						
Sioux Falls, S. Dak.	15	31	46	< 1	2	2
Chena River:						
Fairbanks, Alaska	1	2	3	0	< 1	< 1
Clearwater River:						
Lewiston, Idaho	1	3	4	0	0	0
Clinch River:						
Clinton, Tenn.	1	3	4	0	0	0
Kingston, Tenn ª	6	15	21	0	0	0
Colorado River:						
Loma, Colo.	2	12	14	0	8	8
Parker Dam, Calif-Ariz.	0	16	16	0	4	4
Columbia River:						
Wenatchee, Wash.	1	3	4	0	1	1
Pasco, Wash ª	44	399	443	< 1	< 1	< 1
Clatskanie, Ore.	11	26	37	0	< 1	< 1
Connecticut River:						
Enfield Dam, Conn.	1	4	5	0	0	0
Delaware River:						
Philadelphia, Pa.	1	5	6	0	0	0
Great Lakes:						
Duluth, Minn.	1	3	4	0	0	0
Green River:						
Dutch John, Utah	1	15	16	0	3	3
Hudson River:						
Poughkeepsie, N.Y.	1	5	6	0	0	0
Illinois River:						
Peoria, Ill.	15	9	24	5	1	6
Grafton, Ill.	3	11	14	1	0	1
Kansas River:						
DeSoto, Kans.	2	16	18	0	2	2
Klamath River:						
Keno, Ore.	2	7	9	0	0	0
Maumee River:						
Toledo, Ohio	10	25	35	2	2	4
Mississippi River:						
St. Paul, Minn.	1	14	15	0	1	1
E. St. Louis, Ill.	1	12	13	0	1	1
New Roads, La.	2	11	13	1	1	2
New Orleans, La.	0	11	11	0	2	2
Missouri River:						
Williston, N. Dak.	2	11	13	0	5	5
Bismarck, N. Dak.	7	16	23	1	3	4
St. Joseph, Mo.	7	19	26	1	3	4
North Platte River:						
Henry, Nebr.	8	35	43	1	31	32
Ohio River:						
Cairo, Ill.	6	7	13	1	0	1
Pend Oreille River:						
Albeni Falls Dam, Idaho	< 1	4	4	0	< 1	< 1
Platte River:						
Plattsmouth, Nebr.	10	24	34	2	6	8
Potomac River:						
Washington, D.C.	1	6	7	0	0	0
Rainy River:						
Baudette, Minn.	1	12	13	0	0	0
Red River, North:						
Grand Forks, N. Dak.	0	17	17	0	1	1
Red River, South:						
Alexandria, La.	2	18	20	0	1	1
Rio Grande:						
El Paso, Tex.	1	14	15	0	3	3
Laredo, Tex.	8	12	20	2	5	7
San Joaquin River:						
Vernalis, Calif.	2	5	7	0	2	2
San Juan River:						
Shiprock, N. Mex.	32	12	44	12	5	17
Savannah River:						
Port Wentworth, Ga ª	3	12	15	0	0	0
Snake River:						
Payette, Idaho	2	12	14	0	5	5
Wawawai, Wash.	2	9	11	0	3	3
South Platte River:						
Julesburg, Colo.	20	71	91	4	45	49
Susquehanna River:						
Conowingo, Md.	1	5	6	0	0	0
Tennessee River:						
Chattanooga, Tenn.	1	5	6	0	0	0
Yellowstone River:						
Sidney, Mont.	4	14	18	1	4	5
Maximum	44	399	443	12	45	49
Minimum	0	2	3	0	0	0

ª Gross beta activity at this station may not be directly comparable to gross beta radioactivity at other stations because of the possible contribution of radionuclides from an upstream nuclear facility in addition to the contribution from fallout and naturally occurring radionuclides, common to all stations.

REFERENCES

(1) PUBLIC HEALTH SERVICE, DIVISION OF WATER SUPPLY AND POLLUTION CONTROL. National water quality network annual compilation of data, PHS Publication No. 663, 1958 Edition. Superintendent of Documents, U.S Government Printing Office, Washington, D.C. 20402.

(2) *Ibid.*, 1959 Edition.

(3) *Ibid.*, 1960 Edition.

(4) *Ibid.*, 1961 Edition.

(5) *Ibid.*, 1962 Edition.

(6) PUBLIC HEALTH SERVICE, DIVISION OF WATER SUPPLY AND POLLUTION CONTROL. Water pollution surveillance system, annual compilation of data, PHS Publication No. 663 (Revised), 1963 Edition. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

SECTION III. AIR AND DEPOSITION

Radioactivity in Airborne Particulates and Precipitation

Continuous surveillance of radioactivity in air and precipitation provides one of the earliest indications of changes in environmental fission product activity. To date, this surveillance has been confined chiefly to gross beta analysis. Although such data are insufficient to assess total human radiation exposure from fallout, they can be used to determine when to modify monitoring in other phases of the environment.

Surveillance data from a number of programs are published monthly and summarized periodically to show current and long-range trends of atmospheric radioactivity in the Western Hemisphere. These include data from activities of the Public Health Service, the Canadian Department of National Health and Welfare, the Mexican Commission of Nuclear Energy, and the Pan American Health Organization.

An intercomparison of the above networks was performed by Lockhart and Patterson (*1*) in 1962 and is summarized in the January 1964 issue of *Radiological Health Data*. In addition to those programs presented in this issue, the following programs were previously covered in *Radiological Health Data and Reports:*

Network	Period	Issue
HASL Fallout Network	July–December 1965	September 1966
HASL 80th Meridan Network	Calendar year 1965	January 1967

1. Radiation Surveillance Network
January 1967

National Center for Radiological Health and
U.S. Public Health Service

Surveillance of atmospheric radioactivity in the United States is conducted by the Radiation Surveillance Network (RSN), which regularly gathers samples at 74 stations distributed throughout the country (figure 1). Most of the stations are operated by State health department personnel.

Daily samples of airborne particulates and precipitation are forwarded to the Radiation Surveillance Network Laboratory in Rockville, Md., for laboratory analysis. The alerting function of the network is provided by routine field estimates of the gross beta radioactivity made by the station operators prior to submission of the samples for laboratory analysis. When high air activity is reported, appropriate officials are promptly notified. Compilation of field estimates and laboratory confirmations are reported elsewhere on a monthly basis (*2*). A detailed description of the sampling and analytical procedures was presented in the November 1966 issue of *Radiological Health Data and Reports.*

Table 1 presents the monthly average gross beta radioactivity in surface air and deposition by precipitation during January 1967. Time profiles of gross beta in air for eight RSN stations are shown in figure 2.

Debris from the Chinese mainland atmospheric nuclear test of December 27, 1966 EST, crossed the United States for the first time during the first week of January 1967 and resulted in peak air gross beta radioactivity levels at many stations that were higher than have been noted since late 1962. Sixty air samples were above 10 pCi/m³. The three samples listed in table 2 exceeded 100 pCi/m³ at the time of collection. Four hundred and eighty gamma scans were performed on 467 air samples. Three hundred and twenty-nine of these were positive for fresh fission products.

Precipitation samples contained substantially higher radioactivity levels. The pattern of deposition was comparable in magnitude, but different in distribution, to the May 1966 findings.

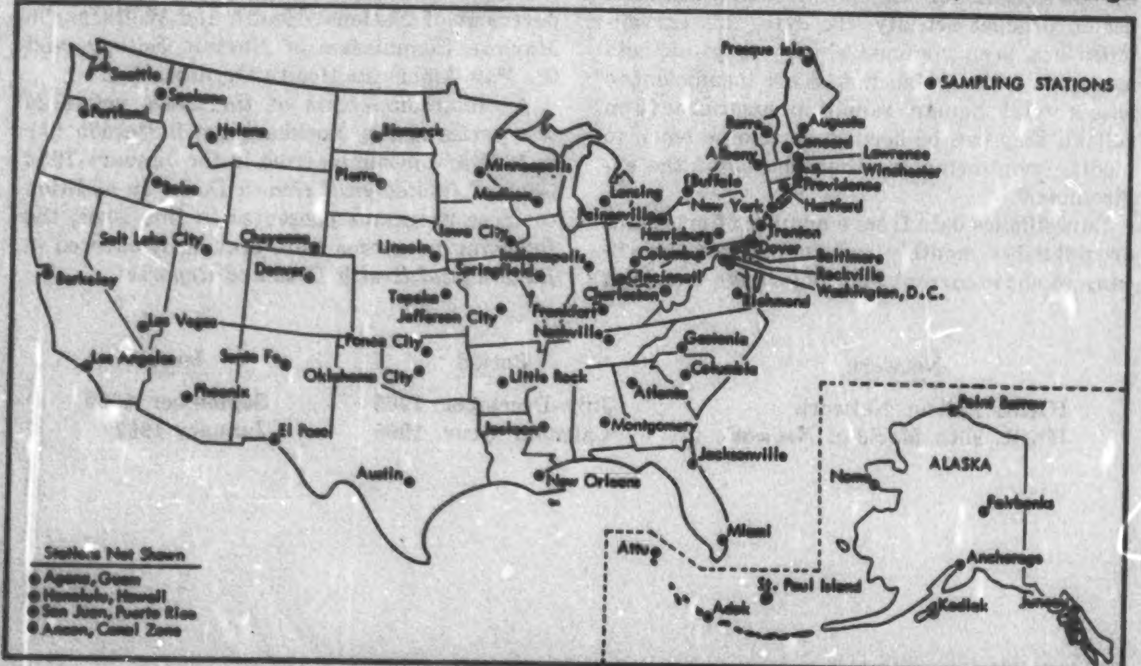

● SAMPLING STATIONS
Seattle
Spokane
Portland
Helena
Bismarck
Boise
Pierre
Minneapolis
Madison
Salt Lake City
Cheyenne
Lincoln
Iowa City
Indianapolis
Springfield
Berkeley
Denver
Topeka
Jefferson City
Frankfort
Las Vegas
Nashville
Ponca City
Los Angeles
Santa Fe
Oklahoma City
Little Rock
Phoenix
El Paso
Jackson
Austin
New Orleans
Presque Isle
Augusta
Barre
Concord
Albany
Lawrence
Winchester
Providence
Hartford
Buffalo
Lansing
New York
Painesville
Harrisburg
Trenton
Dover
Columbus
Baltimore
Rockville
Cincinnati
Washington, D.C.
Charleston
Richmond
Gastonia
Columbia
Atlanta
Montgomery
Jacksonville
Miami
ALASKA
Point Barrow
Nome
Fairbanks
Attu
Anchorage
St. Paul Island
Adak
Kodiak
Juneau
Stations Not Shown
● Agana, Guam
● Honolulu, Hawaii
● San Juan, Puerto Rico
● Ancon, Canal Zone

Figure 1. Radiation Surveillance Network sampling stations

Table 1. Gross beta radioactivity in surface air and precipitation, January 1967

Station location		Number of samples		Air surveillance gross beta radioactivity (pCi/m³)			Last profile in *RHD&R*	Precipitation	
		Air	Pptn	Maximum	Minimum	Average [a]		Total depth (mm)	Total deposition (nCi/m²)
Ala:	Montgomery	30	5	44.86	0.02	2.81	--------	99	<90
Alaska:	Adak	31	------	.84	.00	.22	--------	(c)	
	Anchorage	19	3	.61	.06	.20	--------	14	<3
	Attu Island	28	------	.60	.00	.13	--------	(c)	
	Fairbanks	16	4	.15	.02	.06	--------	6	<3
	Juneau	19	10	.43	.00	.12	--------	196	<67
	Kodiak	13	------	1.57	.04	.28	--------	(c)	
	Nome	(b)	------	------	------	------	--------	(c)	
	Pt. Barrow	26	------	.21	.04	.12	--------	(c)	
	St. Paul Island	(b)	------	------	------	------	--------	(c)	
Ariz:	Phoenix	31	------	56.66	.10	2.36	--------	(c)	
Ark:	Little Rock	30	4	7.47	.05	.65	--------	87	<18
Calif:	Berkeley	31	10	66.78	.06	7.83	--------	245	<68
	Los Angeles	31	4	10.61	.07	3.19	--------	157	<81
C.Z:	Ancon	14	------	.07	.01	.08	--------	(c)	
Colo:	Denver	30	4	66.16	.03	2.41	--------	14	<8
Conn:	Hartford	31	6	17.89	.01	1.94	--------	40	<23
Del:	Dover	30	------	43.06	.03	2.20	--------	(c)	
D.C:	Washington	28	6	28.46	.08	1.30	--------	24	26
Fla:	Jacksonville	29	8	25.26	.01	1.50	--------	24	<7
	Miami	30	6	66.60	.01	2.37	--------	75	<19
Ga:	Atlanta	29	5	111.29	.03	5.26	--------	119	<36
Guam:	Agana	29	------	.58	.00	.06	--------	(c)	
Hawaii:	Honolulu	31	4	4.78	.01	.78	--------	36	<16
Idaho:	Boise	31	5	94.71	.04	6.27	--------	17	<60
Ill:	Springfield	31	4	14.30	.05	1.13	--------	29	<15
Ind:	Indianapolis	30	5	10.10	.03	.72	--------	40	<44
Iowa:	Iowa City	30	10	17.54	.06	1.29	--------	22	255
Kans:	Topeka	31	3	6.35	.02	.58	--------	14	<5
Ky:	Frankfort	27	3	26.50	.03	1.50	--------	15	<7
La:	New Orleans	31	10	27.62	.02	2.10	--------	80	<59
Maine:	Augusta	31	9	4.06	.03	.53	--------	55	<30
	Presque Isle	19	------	3.45	.03	.35	--------	(c)	
Md:	Baltimore	21	2	38.81	.00	1.73	--------	10	4
	Rockville	14	------	36.38	.05	1.63	--------	(c)	
Mass:	Lawrence	30	7	36.55	.03	1.54	--------	38	<9
	Winchester	25	8	25.38	.03	1.31	--------	53	<16
Mich:	Lansing	30	------	13.38	.04	.85	--------	(c)	
Minn:	Minneapolis	30	9	1.22	.06	.28	--------	70	<36
Miss:	Jackson	30	3	6.94	.01	.64	--------	43	<10
Mo:	Jefferson City	30	3	7.70	.06	.70	--------	37	<10
Mont:	Helena	31	3	10.72	.02	.74	--------	11	<4
Nebr:	Lincoln	19	1	.33	.00	.12	--------	5	2
Nev:	Las Vegas	28	------	119.35	.03	6.26	--------	(c)	
N.H:	Concord	30	------	20.35	.00	1.34	--------	(c)	
N.J:	Trenton	31	3	14.21	.02	.96	--------	5	<3
N. Mex:	Santa Fe	26	1	23.17	.06	1.47	--------	6	1
N.Y:	Albany	31	5	6.89	.04	.54	--------	25	<9
	Buffalo	24	------	11.71	.02	.06	--------	(c)	
	New York	31	------	12.06	.03	.08	--------	(c)	
N.C:	Gastonia	30	7	24.14	.02	1.13	--------	9	<30
N. Dak:	Bismarck	31	6	9.74	.04	.83	--------	16	12
Ohio:	Cincinnati	17	------	19.73	.07	1.79	--------	(c)	
	Columbus	31	3	23.30	.06	1.45	--------	16	<4
	Painesville	28	5	6.45	.04	.54	--------	25	<31
Okla:	Oklahoma City	30	3	5.87	.03	.56	--------	38	<5
	Ponca City	30	2	5.39	.02	.26	--------	20	<4
Oreg:	Portland	30	23	81.64	.02	2.60	--------	142	2,545
Pa:	Harrisburg	30	3	29.95	.03	1.37	--------	43	15
P.R:	San Juan	31	7	.20	.02	.06	--------	100	<30
R.I:	Providence	30	6	19.86	.02	1.01	--------	41	<11
S.C:	Columbia	29	7	.65	.01	.21	--------	53	<15
S. Dak:	Pierre	30	------	28.96	.02	1.51	--------	(c)	
Tenn:	Nashville	31	4	31.96	.03	1.54	--------	37	<51
Tex:	Austin	30	4	55.00	.04	2.75	--------	6	<31
	El Paso	30	------	28.38	.07	3.10	--------	(c)	
Utah:	Salt Lake City	30	10	104.52	.03	4.77	--------	70	<125
Vt:	Barre	30	7	9.30	.04	.60	--------	33	<205
Va:	Richmond	30	6	26.83	.01	1.33	--------	21	<62
Wash:	Seattle	30	20	8.96	.01	.61	--------	157	<73
	Spokane	31	5	36.49	.02	2.13	--------	38	<61
W. Va:	Charleston	29	9	17.53	.04	1.47	--------	25	<21
Wis:	Madison	30	6	10.13	.03	.73	--------	77	<255
Wyo:	Cheyenne	31	3	10.38	.02	.98	--------	8	<2
Network summary		1,089	314	119.35	0.00	1.45	--------	51	<86

---

[a] The monthly average is calculated by weighting the individual samples with length of sampling period. Values of 0.005 pCi/m³ or less are reported and used in averaging as 0.00 pCi/m³.

[b] No report received.

[c] No precipitation sample collected.

-98-

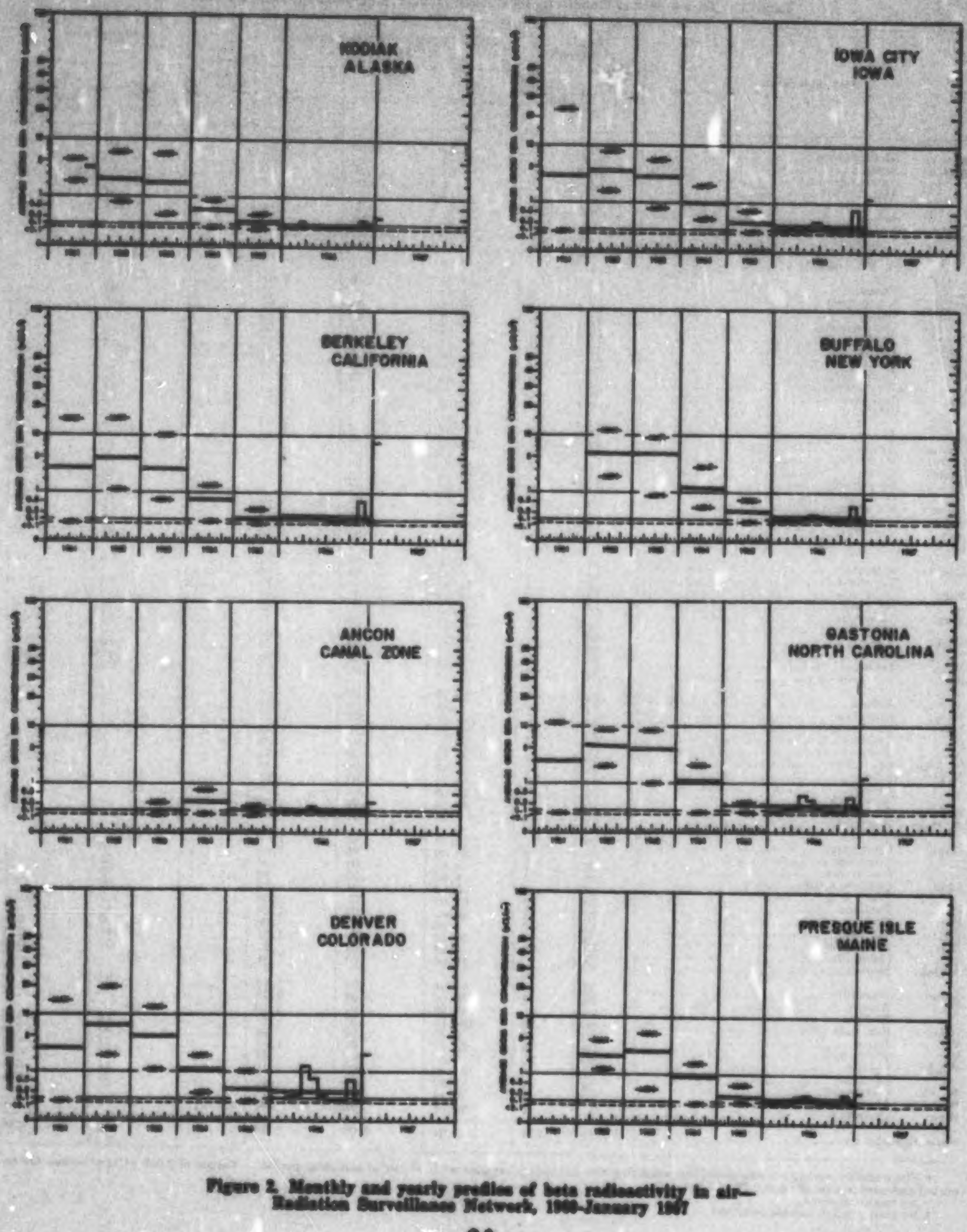


Figure 2. Monthly and yearly profiles of beta radioactivity in air—Radiation Surveillance Network, 1960-January 1967

-99-

Table 2. RSN stations with gross beta radioactivity in excess of 100 pCi/m²

Location	Date	Radioactivity (pCi/m²)
Las Vegas, Nev.	1/3/67	119.38
Salt Lake City, Utah	1/3/67	104.88
Atlanta, Ga.	1/4/67	111.28

The deposition in Portland, Ore., is the highest single monthly deposition since the present data collection system was established in November 1961. Precipitation samples analyzed by gamma-ray spectrometry yielded positive results for fresh fission products.

---

2. Canadian Air and Precipitation Monitoring Program, January 1967 [1]

Radiation Protection Division
Department of National Health and Welfare

The Radiation Protection Division of the Canadian Department of National Health and Welfare monitors surface air and precipitation in connection with its Radioactive Fallout Study Program. Twenty-four collection stations are located at airports (figure 3), where the sampling equipment is operated by personnel from the Meteorological Services Branch of the Department of Transport. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports of the Department of National Health and Welfare (*2–6*).

A summary of the sampling procedures and methods of analysis was presented in the November 1966 issue of *Radiological Health Data and Reports*.

Surface air and precipitation data for January 1967 are presented in table 3.

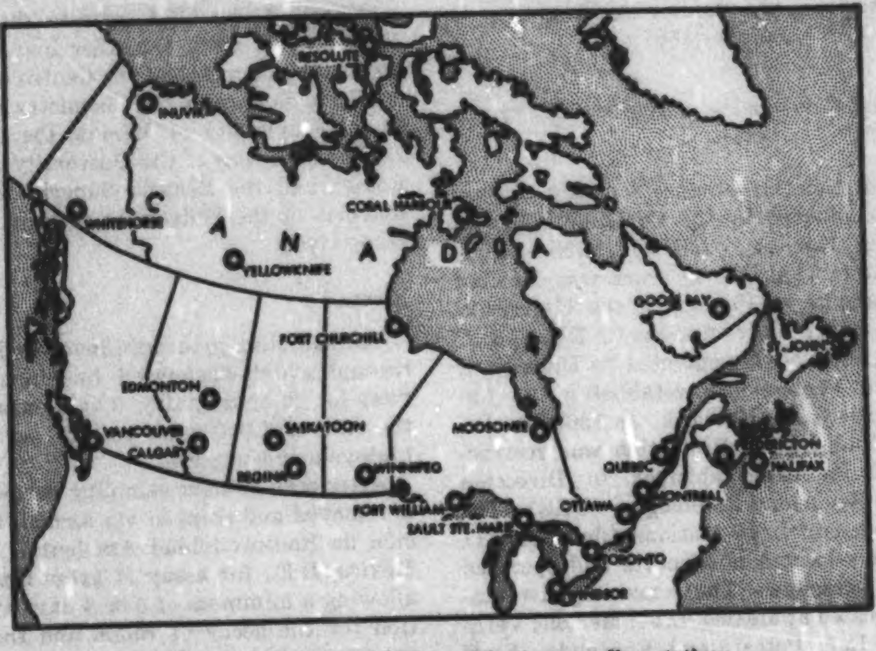

RESOLUTE
INUVIK
WHITEHORSE
CORAL HARBOUR
C A N A D A
YELLOWKNIFE
FORT CHURCHILL
GOOSE BAY
ST. JOHN'S
EDMONTON
SASKATOON
VANCOUVER
CALGARY
REGINA
WINNIPEG
MOOSONEE
FREDERICTON
HALIFAX
QUEBEC
MONTREAL
OTTAWA
FORT WILLIAM
SAULT STE. MARIE
TORONTO
WINDSOR

Figure 3. Canadian air and precipitation sampling stations

---

[1] Prepared from information and data in the February 1967 monthly report "Data from Radiation Protection Program," Canadian Department of National Health and Welfare, Ottawa, Canada.

-100-

Table 3. Canadian gross beta radioactivity in surface air and precipitation, January 1967

Station	Number of samples	Air surveillance radioactivity (pCi/m³)			Precipitation measurements	
		Maximum	Minimum	Average	Average concentrations (pCi/liter)	Total deposition (nCi/m²)
Calgary	31	290.0	0.1	13.2	271	5.0
Coral Harbour	29	6.3	.1	.6	646	6.4
Edmonton	31	32.0	.1	1.7	174	5.1
Ft. Churchill	31	.8	.0	.3	26	.8
Ft. William	31	6.2	.0	.7	257	8.1
Fredericton	30	13.5	.0	1.3	159	10.8
Goose Bay	31	.3	.1	.2	NS	NS
Halifax	31	4.3	.0	.5	62	4.6
Inuvik	31	1.4	.0	.2	79	1.5
Montreal	31	36.0	.1	3.5	943	53.1
Moosonee	31	6.8	.1	.6	49	1.4
Ottawa	31	80.0	.1	3.0	671	47.3
Quebec	31	3.6	.0	.7	354	24.4
Regina	31	14.0	.1	1.4	166	4.5
Resolute	31	2.0	.1	.4	272	.3
St. John's, Nfld	31	1.4	.1	.3	99	5.2
Saskatoon	31	5.7	.1	.6	332	4.0
Sault Ste. Marie	31	3.3	.1	.6	190	10.8
Toronto	31	86.0	.0	3.6	1,432	78.8
Vancouver	31	3.3	.0	.3	96	8.3
Whitehorse	31	.4	.0	.2	119	2.4
Windsor	31	17.0	.1	1.3	101	5.3
Winnipeg	31	19.4	.1	1.6	122	2.5
Yellowknife	31	5.3	.1	.4	307	1.8
Network summary	741	290.0	0.0	1.5	286	13.1

NS, no sample.

3. Mexican Air Monitoring Program January 1967

National Commission of Nuclear Energy

The Radiation Surveillance Network of Mexico was established by the Comisión Nacional de Energía Nuclear (CNEN), México, D.F. From 1952 to 1961, the network was directed by the Institute of Physics of the University of Mexico, under contract to the CNEN.

In 1961, the CNEN appointed its Division of Radiological Protection to establish a new Radiation Surveillance Network. In 1966, the Division of Radiological Protection was restructured and its name changed to Dirección General de Seguridad Radiológica (DRS). The network consists of 16 stations (figure 4), 11 of which are located at airports and operated by airline personnel. The remaining five stations are located at México, D.F.; Mérida; Veracruz; San Luis Potosí; and Ensenada. Staff members of the DRS operate the station at México, D.F., while the other four stations are manned by members of the Céntro de Previsión del Golfo de México, the Chemistry Department of the University of Mérida, the Instituto de Zonas Desérticas of the University of San Luis Potosí, and the Escuela Superior de Ciencias Marinas of the University of Baja California, respectively.

Sampling

The sampling procedure involves drawing air through a high-efficiency 6- by 9-inch glass-fiber filter for 20 hours a day, 3 or 4 days a week at the rate of 1,000 cubic meters per day using high-volume samplers.

After each 20-hour sampling period, the filter is removed and shipped via airmail to the Sección de Radioactividad Ambiental, CNEN, in México, D.F., for assay of gross beta activity, allowing a minimum of 3 or 4 days after collection for the decay of radon and thoron. The data are not extrapolated to the time of collec-

- 101 -

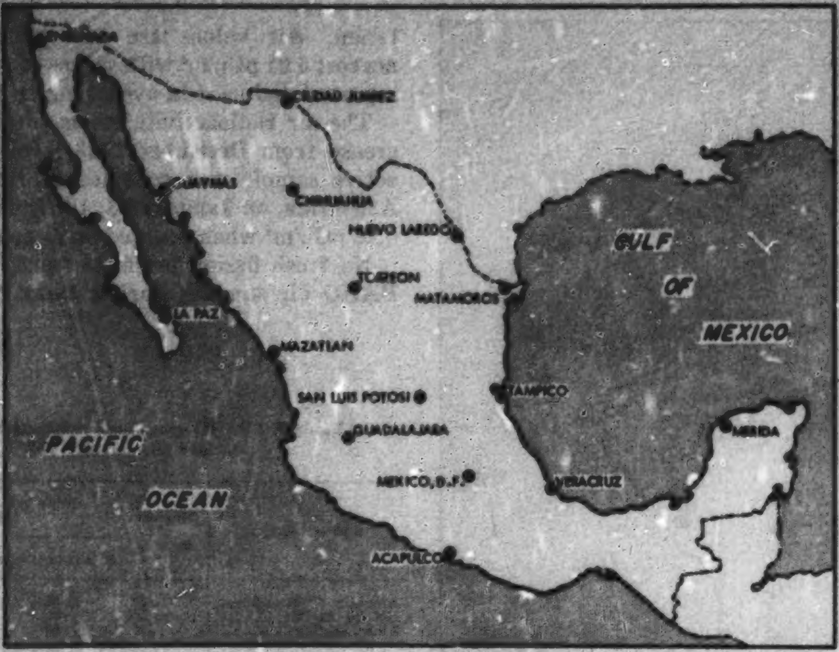

ENSENADA
CIUDAD JUAREZ
GUAYMAS
CHIHUAHUA
NUEVO LAREDO
TORREON
MATAMOROS
LA PAZ
MAZATLAN
SAN LUIS POTOSI
TAMPICO
GUADALAJARA
MERIDA
MEXICO, D.F.
VERACRUZ
ACAPULCO
PACIFIC
OCEAN
GULF
OF
MEXICO

Figure 4. Mexican air sampling locations

tion. Statistically, it has been found that a minimum of eight samples per month were needed to get a reliable average activity at each station (7).

The maximum, minimum, and average gross beta radioactivity in surface air during January 1967 are presented in table 4.

Table 4. Mexican gross beta radioactivity of airborne particulates, January 1967

Station	Number of samples	Gross beta radioactivity (pCi/m³)		
		Maximum	Minimum	Average
Acapulco	8	0.2	<0.1	0.1
Chihuahua	10	.7	.1	.2
Ciudad Juárez	3	4.6	.6	
Ensenada	6	.6	.1	.2
Guadalajara	2			
Guaymas	9	.7	.1	.3
La Paz	3	.3	.1	.1
Matamoros	NS			
Mazatlán	8	.2	< .1	.1
Mérida	3	.4	.1	
México, D.F.	3	.1	< .1	
Nuevo Laredo	7	.4	.1	.1
San Luis Potosí	1			
Tampico	9	.1	< .1	.1
Torreón	8	.3	.1	.2
Veracruz	7	.2	< .1	.1

NS, no sample collected, station temporarily shut down.

4. Pan American Air Sampling Program January 1967

Pan American Health Organization and *U.S. Public Health Service*

Gross beta radioactivity in air is monitored by countries in the Americas under the auspices of the collaborative program developed by the Pan American Health Organization (PAHO) and the U.S. Public Health Service (PHS) to assist PAHO-member countries in developing radiological health programs. The sampling equipment and analytical services are provided by the National Center for Radiological Health, PHS, and are identical with those employed by the Radiation Surveillance Network. The air-sampling station positions are shown in figure 5.

The January 1967 air-monitoring results from the participating countries are given in table 5. Two changes from previous reports are the addition of a station at La Paz, Bolivia, and change in minimum reporting levels and

-102-

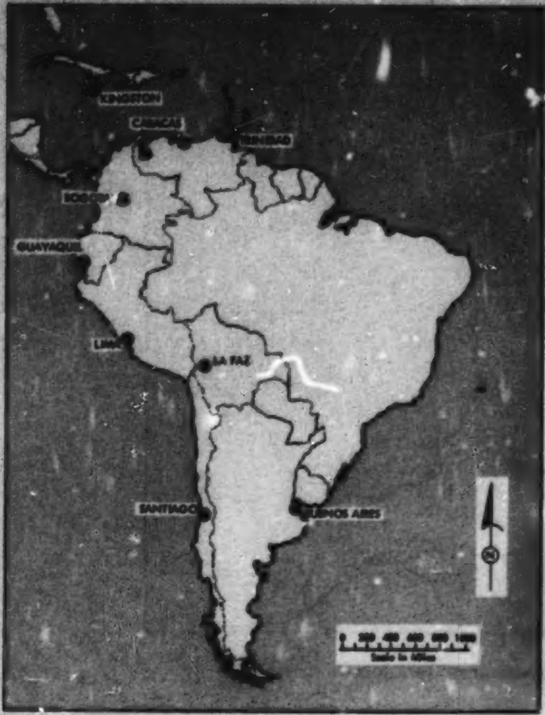


Figure 5. Pan American Air Sampling Program stations

conventions. The change involves the elimination of the "less than" sign (<) from the tabulation. Air values are now rounded to the nearest 0.01 pCi/m³ with values of 0.0050 or less reported and used in averaging as 0.00 pCi/m³.

The air radioactivity levels continued to decrease from December 1966 levels. The most active sample was collected at Buenos Aires, Argentina, on January 18, 1967, and measured 0.28 pCi/m³ when counted on January 23, 1967.

No fresh fission products were identified on PAHO air samples during January 1967.

Table 5. PAHO gross beta radioactivity in surface air, January 1967

Station location	Number of samples	Gross beta radioactivity (pCi/m³)		
		Maximum	Minimum	Average [a]
Argentina: Buenos Aires	25	0.28	0.08	0.17
Bolivia: La Paz	25	.09	.00	.05
Chile: Santiago	25	.20	.03	.11
Colombia: Bogota	20	.11	.00	.02
Ecuador: Guayaquil	25	.15	.01	.05
Jamaica: Kingston	10	.05	.02	.03
Peru: Lima	3	.11	.08	.09
Venezuela: Caracas	17	.11	.01	.04
West Indies: Trinidad	21	.14	.01	.05
Pan American summary	171	0.28	0.00	0.06

[a] The monthly average is calculated by weighting the individual samples with length of sampling period.

5. Plutonium in Airborne Particulates October–December 1966

National Center for Radiological Health
U.S. Public Health Service

The Radiation Surveillance Network (RSN) of the National Center for Radiological Health, Public Health Service, located at Rockville, Maryland, is continuing routine analysis for plutonium in air particulates. These analyses were initiated during 1965 as part of the mission to establish, maintain, and operate a national surveillance network to measure radioactivity in the environment.

Air filters from 11 RSN stations are analyzed monthly for plutonium. Each daily filter is counted for gross beta radioactivity and for gamma-ray emitters by gamma spectroscopy 4 to 5 days after collection. For plutonium analysis, a monthly composite is made of one-half of each individual sample for each station. Each composite, representing 10,000 to 20,000

Table 6. Plutonium in airborne particulates October–December 1966

Sampling location	Plutonium content [a] (pCi/1,000m³)		
	October	November	December
Alaska: Anchorage	0.034	0.036	0.036
Ariz: Phoenix	.067	.033	.033
Colo: Denver	.042	.041	.098
Hawaii: Honolulu	.039	.079	.034
La: New Orleans	.048	.028	.043
Md: Rockville	.040	.038	.033
N.Y: Buffalo	.034	.063	.033
N.C: Gastonia	.036	.046	.036
S. Dak: Pierre	.027	.036	.032
Tex: Austin	.034	.047	.043
Wash: Seattle	.031	.027	.080

[a] Plutonium includes ^{238}Pu, ^{239}Pu, and ^{240}Pu.

cubic meters of air, is analysed by gamma-ray spectrometry prior to the plutonium analysis.

Details of the method of collection and radiochemical analyses were presented in an earlier report (8). The results for October through December 1966 are presented in table 6.

REFERENCES

(1) RADIATION SURVEILLANCE NETWORK. Monthly tabulation of findings. National Center for Radiological Health, Public Health Service. Rockville, Md. 20852 (distribution by official request).

(2) BIRD, P. M., A. H. BOOTH, and P. G. MAR. Annual report of 1959 on the Radioactive Fallout Study Program, CNHW-RP-3. Department of National Health and Welfare, Ottawa, Canada (May 1960).

(3) BIRD, P. M., A. H. BOOTH, and P. G. MAR. Annual report for 1960 on the Radioactive Fallout Study Program, CNHW-RP-4. Department of National Health and Welfare, Ottawa, Canada (December 1961).

(4) MAR, P. G. Annual report for 1961 on the Radioactive Fallout Study Program, CNHW-RP-5. Department of National Health and Welfare, Ottawa, Canada (December 1962).

(5) BEALE, J., and J. GORDON. The operation of the Radiation Protection Division Air Monitoring Program, RPD-11. Department of National Health and Welfare, Ottawa, Canada (July 1962).

(6) BOOTH, A. H. The calculation of permissible levels of fallout in air and water and their use in assessing the significance of 1961 levels in Canada, RPD-21. Department of National Health and Welfare, Ottawa, Canada (August 1962).

(7) VASQUEZ, M., and R. H. DeNULMAN. Estudios sobre la Radioactividad Ambiental en la República Mexicana, 1962-1965. Comisión Nacional de Energía Nuclear. Dirección General de Seguridad Radiológica (en prensa 1966).

(8) RUSSELL, J., H. LEVINE, and R. SCHNEIDER. Plutonium in airborne particulates. Radiol Health Data Rep 7:483-484 (August 1966).

-104-

SECTION IV. OTHER DATA

This section presents results from routine sampling of biological materials and other media not reported in the previous sections. Included are such data as those obtained from human bone sampling, bovine thyroid sampling, Alaskan surveillance, and environmental monitoring reports.

Radionuclides in Alaskan Caribou and Reindeer October–November 1966

National Center for Radiological Health
U.S. Public Health Service

Under a cooperative agreement between the Alaskan Department of Health and Welfare, the Alaskan Department of Fish and Game, and the U.S. Public Health Service, an active program of caribou and reindeer sampling and analysis was undertaken in 1963 to aid in the assessment of radionuclide intake of Alaskan residents. The basis for this joint sampling activity was a limited sampling effort conducted by these groups in 1962.

Through the second quarter of 1964, the sampling was confined to the three principal caribou (*Rangifer caribou*) herds and one privately owned reindeer (*Rangifer tarandus*) herd. This program was expanded in September 1964, when the sampling of additional privately owned reindeer herds was begun through the assistance of the Fish and Wildlife Service and the Bureau of Indian Affairs, Department of Interior.

Figure 1 shows the locations and approximate number of animals in the caribou and reindeer herds sampled during the fall of 1966.

For the present program, samples are taken in the spring and fall from selected caribou and reindeer herds. Five muscle and rumen content samples are obtained from each herd during the sampling period. Five hock bones are collected from the Nome herd at the fall collection period. Muscle samples are analyzed individually and rumen content samples from the same herd are composited before analysis for cesium-137 by gamma-ray spectroscopy. Muscle and bone samples from the same herd are composited before analysis for strontium-89 and strontium-90. All samples are analyzed at the Public Health Service's Southwestern Radiological Health Laboratory in Las Vegas, Nev.

Strontium-89, strontium-90, and cesium-137 data are presented in table 1 for caribou and reindeer muscle, rumen contents, and bone for the October–November 1966 collection period. The muscle data are of prime interest, since muscle is an important constituent of the diet for many Alaskan residents. The five herds sampled in the fall of 1966 had average cesium-137 muscle concentrations similar to those found for the fall 1965 samples with the exception of the Arctic herd samples. The average cesium-137 muscle sample concentrations of the Arctic herd were more than double the average for fall 1965 samples and were similar to spring samples. The reason for this is not known, however, it is possible that the Arctic herd was forced to return to a winter diet of lichen and sedges (high in cesium-137 content) earlier this year. A summary of strontium-90 and cesium-137 concentrations in foodstuffs in Alaska (including reindeer and caribou meat) is contained in the December 1966 issue of *Radiological Health Data and Reports*.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
1963–1965	March 1966

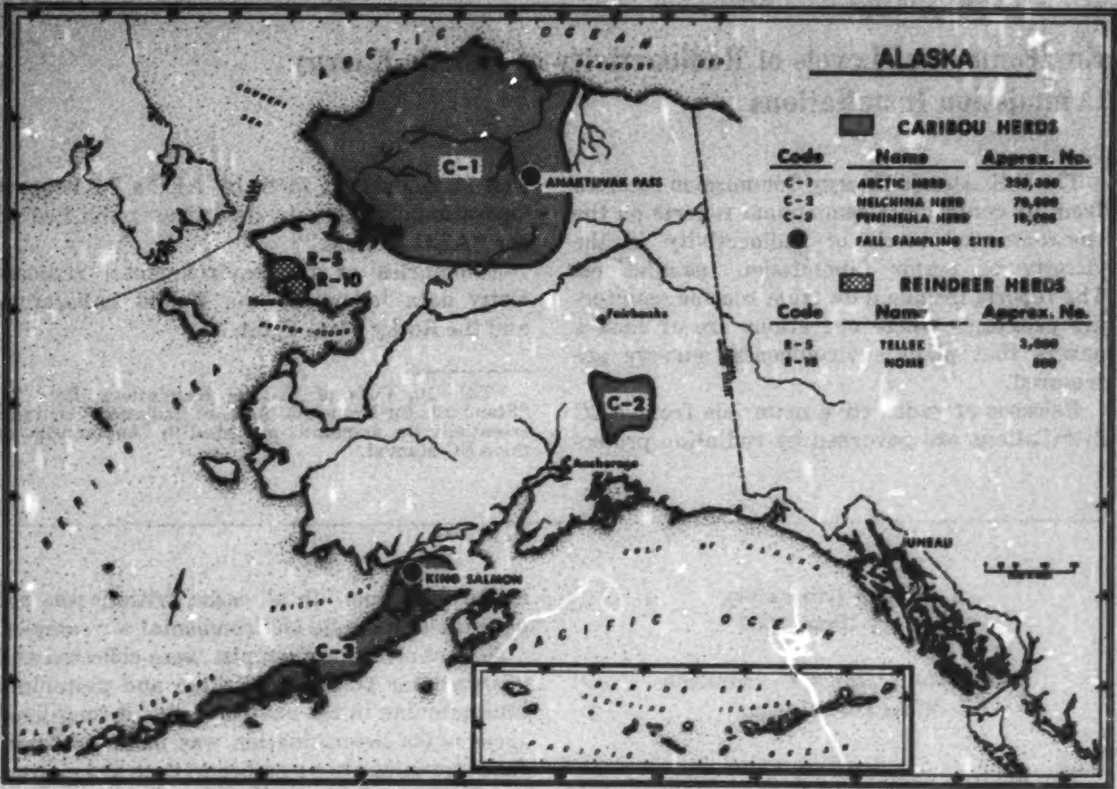

ARCTIC OCEAN
BEAUFORT SEA
ALASKA
CARIBOU HERDS
Code | Name | Approx. No.
C-1 ARCTIC HERD 250,000
C-2 NELCHINA HERD 70,000
C-3 PENINSULA HERD 10,000
FALL SAMPLING SITES
REINDEER HERDS
Code | Name | Approx. No.
R-5 TELLER 3,000
R-10 NOME 800
C-1
ANAKTUVUK PASS
R-5
R-10
Nome
Fairbanks
C-2
Anchorage
JUNEAU
KING SALMON
C-3
BERING SEA
BRISTOL BAY
GULF OF ALASKA
PACIFIC OCEAN

Figure 1. Location and numbers of caribou and reindeer in herds sampled

Table 1. Radionuclide concentrations in muscle, rumen, and bone of Alaskan caribou and reindeer, October–November 1966

Herd and sampling location [a]	Collection date, 1966	Sex	Age (years)	Muscle (pCi/kg wet weight)			Rumen (pCi/kg wet weight)		Bone (pCi/g ash)
				^{89}Sr [b]	^{90}Sr [b]	^{137}Cs	^{90}Sr [b]	^{137}Cs [b]	^{90}Sr [b]
Arctic caribou herd, Anaktuvuk Pass, C-1	10/6	M	2	<5	9	25×10^3	NA	7.9×10^3	NS
	10/12	M	2			10×10^3			
	10/12	M	3			14×10^3			
	10/17	F	5			16×10^3			
	10/18	F	4			20×10^3			
Nelchina caribou herd, Dickey Lake, C-2	10/4	M	4	<5	23	11×10^3	NA	7.2×10^3	NS
	10/4	M	4			12×10^3			
	10/4	F	6			13×10^3			
	10/4	M	4			13×10^3			
	10/4	F	5			14×10^3			
Peninsula caribou herd, King Salmon, C-3	11/2	M	5	<5	5	18×10^3	NA	7.0×10^3	NS
	11/2	F	6			19×10^3			
	11/2	M	1			25×10^3			
	11/2	M	6			19×10^3			
	11/2	M	3			19×10^3			
Teller reindeer herd, R-5	11/25	F	5	<5	9	23×10^3	NA	8.2×10^3	NS
	11/25	M	3			19×10^3			
	11/25	M	4			27×10^3			
	11/25	M	5			25×10^3			
	11/25	M	4			24×10^3			
Nome reindeer herd, R-10	11/9	F	2	NA	377	22×10^3	3,190	12×10^3	187
	11/9	F	2			25×10^3			
	11/9	F	4			28×10^3			
	11/9	F	2			20×10^3			
	11/9	M	2			27×10^3			

[a] Sampling locations are shown on figure 1.
[b] Composite of individual samples taken within the herd.
NA, no analysis.
NS, no sample taken.

Environmental Levels of Radioactivity at Atomic Energy Commission Installations

The U.S. Atomic Energy Commission receives from its contractors semiannual reports on the environmental levels of radioactivity in the vicinity of major Commission installations. The reports include data from routine monitoring programs where operations are of such a nature that plant environmental surveys are required.

Releases of radioactive materials from AEC installations are governed by radiation protection standards set forth by AEC's Division of Operational Safety in directives published in the "AEC Manual." [1]

Summaries of the environmental radioactivity data follow for the Mound Laboratory and the Rocky Flats Plant.

---

[1] Title 10, Code of Federal Regulations, Part 20, "Standards for Protection Against Radiation," contains essentially the standards published in Chapter 0524 of the AEC Manual.

---

1. Mound Laboratory
January–June 1966 [2]

Monsanto Research Corporation
Miamisburg, Ohio

The environmental monitoring program for Mound Laboratory is planned and coordinated with all of the projects conducted at the laboratory. Air and water monitoring in the uncontrolled environs surrounding the laboratory is specific for the radionuclides which could be released to the environment. Only polonium–210, plutonium–239, and hydrogen–3 (tritium) are potential environmental contaminants.

Air monitoring

Mobile air monitoring equipment, mounted on a 1-ton panel truck, for measurement of tritium and collection of particulate alpha emitters was used in the routine monitoring of environmental air in a network of 111 locations within a radius of 20 miles from the laboratory during the collection period. The choice of sites on a given day was dependent upon the wind direction at the time of collection.

During the 6-month period ending June 1966, weekly samples were collected and analysed for airborne tritium. In all cases, tritium was not detectable in offsite environmental air samples.

A total of 212 air samples were collected and analyzed for possible polonium and plutonium contaminants in the environment. A long-lived gross alpha determination was made on filter-paper samples after a sufficient time had elapsed to permit the decay of the short-lived daughter products of radon and thoron. The filter paper samples were counted for alpha-particle emissions in a low-background proportional counter. The average measured concentrations of alpha-particle activity in air are summarized in table 1. No specific determinations of polonium–210 or plutonium–239 were made, since the gross alpha-particle activity remained substantially below the environmental limits for these nuclides.

Table 1. Atmospheric monitoring of long-lived alpha radioactivity, Mound Laboratory environs, January–June 1966

Sampling location	Number of samples	Concentration (pCi/m³)	
		Maximum	Average [a]
Upwind from laboratory......	25	[b] 0.0035	0.0035
Downwind from laboratory....	187	.1112	.0064

[a] The applicable AEC Radiation Protection Standards for uncontrolled areas are as follows:

Polonium-210 in air: 20 pCi/m³
Plutonium-239 in air: 0.06 pCi/m³

[b] The minimum detectable concentration for long-lived alpha radioactivity concentrations in air is 0.0035 pCi/m³.

---

[2] Summarized from "Environmental Monitoring Report: January–June 1966" (MLM-[illegible]).

Water monitoring

Liquid radioactive waste materials from polonium and plutonium operations at the laboratory are processed in special waste disposal plants designed to reduce radioactivity to a concentration at which it may be discharged to the Great Miami River.

Helium-3, which is purified at the Mound Laboratory, contains small quantities of hydrogen-3 (tritium). Liquid wastes from this operation are treated separately to assure that the radioactivity level is below the AEC radiation protection standard before discharge to the Great Miami River.

Weekly water samples are collected from a drainage ditch and six locations along the Great Miami River as shown in figure 1. Additional samples are taken quarterly at more distant downstream points. The drainage ditch carries all storm sewer water and treated liquid tritium and plutonium wastes from the plant site. Sampling location number 3 (figure 1) is the point of discharge of the liquid polonium waste to the Great Miami River; and number 7, at Franklin, Ohio, is 5 miles downstream from the effluent outfall.

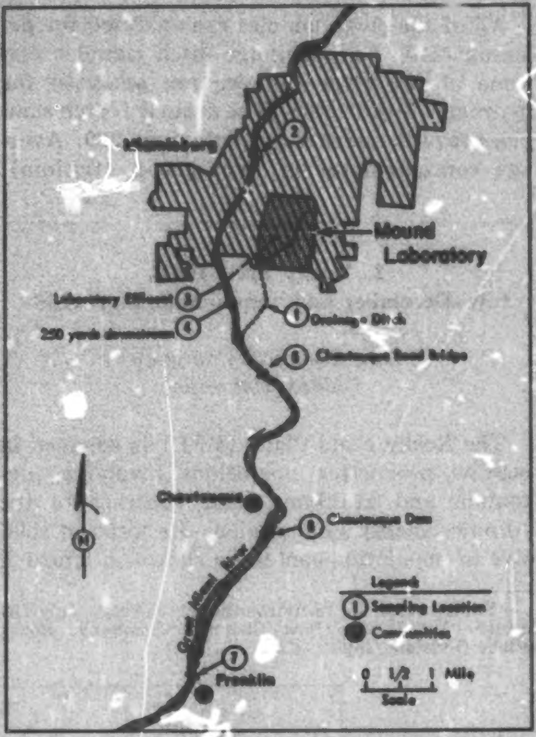


Figure 1. Water sampling locations, Mound Laboratory

Table 2. Offsite water monitoring for radioactivity, Mound Laboratory environs, January–June 1966

Nuclide and sampling location [a]	Number of samples	Concentration (pCi/liter)	
		Maximum	Average [b]
Polonium-210 [c]			
2 (Upstream from laboratory)	26	1.80	1.80
3 (Laboratory effluent)	26	1.68×10^2	1.04×10^2
4 (250-yards downstream)	26	3.60	1.94
5 (Chautauqua Road Bridge)	26	1.80	1.80
6 (Chautauqua Dam)	26	1.80	1.80
7 (Franklin, Ohio)	26	2.70	1.84
Trenton, Ohio	2	1.80	1.80
New Miami, Ohio	2	1.80	1.80
7 miles upstream from New Baltimore, Ohio	2	1.80	1.80
New Baltimore, Ohio	2	1.80	1.80
Elizabethtown, Ohio	2	1.80	1.80
Hydrogen-3 (tritium) [d]			
1 (drainage ditch)	25	7.10×10^6	$.40\times10^6$
2 (Upstream from laboratory)	26	$.23\times10^6$	$.06\times10^6$
3 (Laboratory effluent)	25	3.50×10^6	$.36\times10^6$
5 (Chautauqua Road Bridge)	24	$.27\times10^6$	$.07\times10^6$
Plutonium-239 [e]			
1 (drainage ditch)	25	1.0×10^2	$.3\times10^2$

[a] See figure 1 for numbered sampling locations.

[b] The applicable AEC Radiation Protection Standards for uncontrolled areas are as follows:
Polonium-210 in water: 7×10^2 pCi/liter,
Plutonium-239 in water: 5×10^3 pCi/liter,
Hydrogen-3 in water: 3×10^6 pCi/liter.

[c] Minimum detectable level for polonium-210 in water is 1.80 pCi/liter.

[d] Minimum detectable level for hydrogen-3 in water is 0.05×10^6 pCi/liter.

[e] Minimum detectable level for plutonium-239 in water is 0.09 pCi/liter.

All of the river samples are analyzed for polonium–210. The drainage ditch samples and some of the river samples are analyzed for hydrogen–3 (tritium). The drainage ditch samples are also analyzed for plutonium–239. Average concentrations of hydrogen–3 (tritium), polonium–210, and plutonium–239 are given in table 2 for the first 6 months of 1966.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
January–June 1965	May 1966
July–December 1965	November 1966

2. Rocky Flats Plant
July–December and annual summary 1966[3]

Dow Chemical Company
Golden, Colorado

The Rocky Flats Plant (RFP) is engaged in routine production operations involving plutonium and uranium under contract to the Atomic Energy Commission. Its location relative to population centers is shown in figure 2.

To assure properly controlled release of radioactive materials to the environment, periodic samples of air, water, and vegetation are analyzed for gross alpha-particle activity. The most abundant radioactive material involved in the process is plutonium.

The plant is located about 15 miles northwest of Denver. The surface stratum in this area consists of gravel washed out of the highly mineralized front range of the Rocky Mountains, where heterogeneous low-level deposits of uranium, thorium, and radium exist in the soil. These materials are measurable in most samples of air, water, and vegetation.

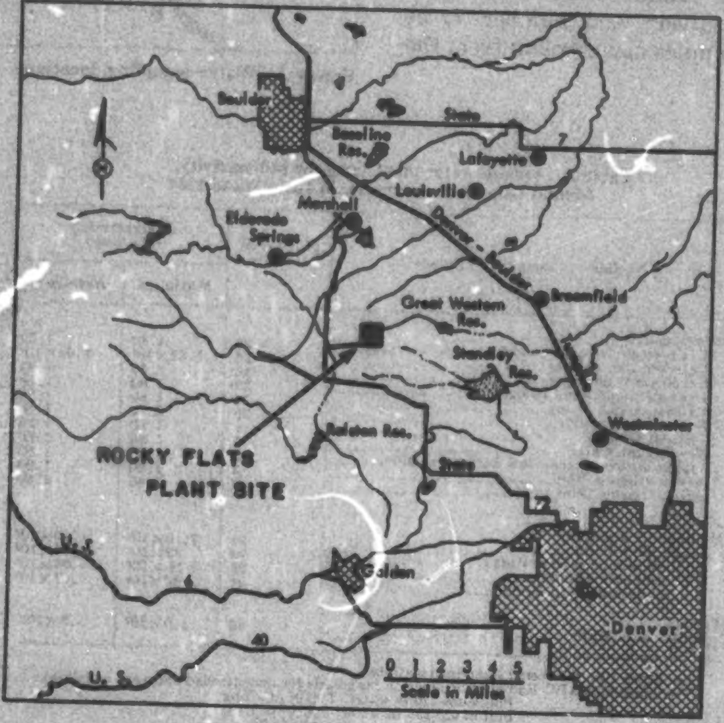

Boulder
Baseline Res.
State
7
Lafayette
Louisville
Marshall
Eldorado Springs
Denver - Boulder
Broomfield
Great Western Res.
Standley Res.
Westminster
Ralston Res.
State
72
ROCKY FLATS PLANT SITE
U. S.
6
Golden
40
U. S.
Denver
0 1 2 3 4 5
Scale in Miles

Figure 2. Rocky Flats Plant and environs near Denver, Colorado

---

[3] Summarized in "Environmental Survey, July–December 1966," The Dow Chemical Company, Rocky Flats Division, Golden, Colo.

Air

Continuous air samples were collected at Coal Creek Canyon, Marshall, Boulder, Lafayette, Broomfield, Wagner School, Golden, Denver, and Westminster. The monthly average long-lived gross alpha-particle activity shown in table 3 are believed to result from naturally occurring materials. All values are less than the AEC Radiation Protection Standard of 0.04 pCi/m³ for mixtures of unidentified radionuclides.

Table 3. Long lived gross alpha radioactivity in airborne particulates, RFP environs, January–December 1966

Period	Average radioactivity (pCi/m³)
January	0.6×10^{-3}
February	$< .6 \times 10^{-3}$
March	$.7 \times 10^{-3}$
April	$.9 \times 10^{-3}$
May	1.0×10^{-3}
June	$< .6 \times 10^{-3}$
July	$.6 \times 10^{-3}$
August	$.7 \times 10^{-3}$
September	$.4 \times 10^{-3}$
October	2.3×10^{-3}
November	$.6 \times 10^{-3}$
December	$.4 \times 10^{-3}$

Water

Regular water samples were obtained once every 2 weeks except during the winter months from four reservoirs in the area of the Rocky Flats Plant. The results of alpha radioactivity analyses performed on these samples are given in table 4. The analytical results for water samples obtained during May and September from outlying streams and lakes are presented in table 5. For comparison purposes, the AEC Radiation Protection Standards for mixtures of unidentified radionuclides in water is 10 pCi/liter.

Table 4. Alpha radioactivity in water, RFP environs, second half and year 1966

Reservoir	Number of samples		Average radioactivity (pCi/liter)	
	Second half 1966	Year 1966	Second half 1966	Year 1966
Great Western	10	18	7.3	6.6
Standley	10	18	7.9	6.0
Baseline	11	19	2.1	1.9
Ralston	8	16	.9	1.6

Table 5. Alpha radioactivity in raw surface waters RFP environs, May and September 1966

Collection period	Number of samples	Average radioactivity (pCi/liter)
May 1966	22	2.4
September 1966	25	3.0

Vegetation

During May 1966, 76 samples of vegetation were collected in the vicinity of Rocky Flats Plant at locations up to 18 miles distant from the plant. Gross alpha radioactivity counts were made on the samples. The results are reported in table 6.

Table 6. Alpha radioactivity in vegetation RFP environs, May 1966

Collection period	Distance from plant	Number of samples	Average radioactivity (pCi/kg dry weight)
May 1966	Less than 3 miles	45	54
	3 to 18 miles	31	64

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
July–December 1965	June 1966
January–June 1966	December 1966

-110-

SECTION V. TECHNICAL NOTES

Radiological Monitoring of the Native Texas Commercial Oyster

J. J. Stanko and M. C. Wukasch[1]

A cooperative agreement was established among the Radiation Surveillance Services group, General Sanitation Services, and laboratory personnel of the Texas State Department of Health, to collect, analyze, and interpret radiation data on the native Texas commercial oyster (*Crassostrea virginica*) (*1*).

The oyster was chosen because of its well-known anatomy and physiology and its economic importance, more than 2,400,000 pounds of meat being harvested during fiscal year 1963 (*2*). The oyster reefs selected for sampling were chosen because of their potential for radioactive contamination, productivity, and accessibility (*3*).

General Sanitation Services, charged with administering the Texas oyster certification program, agreed to collect samples in season for laboratory analyses of radioactive content. The resulting data were compiled and interpreted by the Radiation Surveillance Services group.

Selected Texas certified oyster houses known to harvest from reefs of interest were contacted to obtain their cooperation. Table 1 lists the nearest geographical location, names and coordinates of the sampled reefs, dates of sample collection and analysis, and observed radionuclide activities.

One-quart grab samples of raw oyster meat were obtained from the oyster houses on each of the dates indicated. These were cooled in ice and transported to the State Health Department Laboratory at Austin. Individual quart samples were placed in a 1-liter Marinelli beaker and analyzed for gamma radioactivity, using a 4- by 4-inch NaI (thallium activated) crystal, and a 400-channel analyzer. Samples were then ashed. The ashes were placed in 10-ounce plastic cups and counted again, using the above equipment (*4, 5*).

Two hundred milligrams of ash from each sample were transferred to a 2½-inch stainless-steel planchets and counted for alpha and beta radioactivity. Beta-particle counting was accomplished using a low-background beta-particle counter; alpha-particle counts were obtained using an internal proportional counter (*4, 5*). The radioactivity concentrations in picocuries per gram of ash were calculated from the observed counting rates. The method used is described below.

Alpha radioactivity. Sample radioactivity concentrations were calculated using the following formula, which includes the efficiency factor developed for a 200-mg sample (includes self-absorption, geometry, and back scatter):

$$A(\chi) = \frac{C}{f(\chi) \cdot W \cdot 2.22}$$

---

[1] Mr. Stanko is presently sanitarian, Air Pollution Program, and Mr. Wukasch is chief, Radiation Control Program, Division of Occupational Health and Radiation Control, Texas State Department of Health, Austin, Tex.

Table 1. Sampling locations and analytical results for Texas oyster samples

Sampling location (Texas)	Reef coordinates	Collection date	Analysis date	Gross radioactivity		
				Alpha-particle (pCi/g ash)	Beta-particle (pCi/g ash)	Gamma-ray (cpm/sample)
Sylvan Beach [a]	Unnamed 29° 39' N 95° 01' W	11/10/65	12/1/65	10	48	1.0
Seabrook	Todd's Dump 29° 33' N 94° 57' W	11/10/65	11/22/65	10	88	NDP
Smith Point	Vingtune 29° 30' N 94° 48' W	11/8/65	11/20/65	10	65	NDP
Port Lavaca	Gallinipper Point 28° 38' N 96° 34' W	11/8/65	11/10/65	10	66	NDP
Matagorda	Unnamed 28° 39' N 96° 00' W	12/28/65	12/28/65	18	83	NDP
	Unnamed 28° 39' N 96° 06' W	1/11/66	1/17/66	10	190	1.5
Seadrift	Grassy Point 28° 24' N 96° 47' W	1/11/66	1/12/66	10	110	1.0
Port Lavaca	Gallinipper Point 28° 38' N 96° 34' W	1/11/66	1/12/66	10	165	1.0

[a] Control sample.
NDP, no detectable peaks other than naturally occurring potassium-40.

where $A(\alpha)$ = alpha radioactivity concentration (pCi/g),
C = net observed activity (cpm),
W = sample weight (g),
$f(\alpha)$ = efficiency factor (cpm/dpm), 0.50,
and 2.22 = conversion factor (dpm/pCi).

Beta radioactivity. Beta radioactivity concentrations were calculated in a similar manner:

$$A(\beta) = \frac{C}{f(\beta) \cdot W \cdot 2.22}$$

where $A(\beta)$ = beta radioactivity concentration (pCi/g),
and $f(\beta)$ = efficiency factor (cpm/dpm), 0.154.

Gamma radioactivity. Printout tapes and corresponding spectrum plots were visually inspected. Radionuclide levels were, in general, limited to varying concentrations of naturally occurring potassium-40. When the potassium-40 concentration was stripped out of the gamma-ray spectrum, it was apparent that the beta-particle activities in all samples could be attributed to this naturally occurring isotope.

Four samples displayed a small peak at an energy of 1.12 MeV, corresponding to the gamma-ray energy of zinc-65 (*6–8*). Table 1 also presents the analytical results obtained during this study.

The monitoring of radioactivity levels in Texas oysters has served a twofold purpose:

1. The establishment of baseline levels from which the extent of possible future contamination can be assessed.
2. The maintenance of a surveillance program in the vicinity of potential sources of contamination for the purpose of detecting and measuring any possible radioactive discharges.

REFERENCES

(*1*) EURE, J. A., and C. R. BARDEN. Radiological Monitoring of the Marine Environment, a Survey of State Activities. Division of Occupational Health and Radiation Control, Texas State Department of Health, Austin, Tex. (June 1963).

(*2*) TEXAS PARKS AND WILDLIFE DEPARTMENT. The Texas Oyster Fishery, Bull No. 40. Austin, Tex.

(*3*) EURE, J. A., and M. C. WUKASCH. The Galveston Environmental Surveillance Program, One Year of Operation Interim Report. Division of Occupational Health and Radiation Control, Texas State Department of Health, Austin, Tex.

(*4*) GOLDIN, A. S., and B. KAHN. Analytical radiochemistry in health physics. Health Physics 11:935-944 (1965).

(*5*) SOUTHEASTERN RADIOLOGICAL HEALTH LABORATORY. Procedures for the Determination of Stable Elements and Radionuclides in Environmental Samples. Editors, C. R. Porter, R. J. Augustine, J. M. Matusak, Jr., and M. W. Carter, Montgomery, Ala. 36101.

(*6*) MENZIES, R. A. The Uptake of Zinc in Certain Marine Organisms. Unpublished Master of Science Thesis, University of Florida, Gainesville, Fla. (August 1962).

(*7*) CHANNEL, J. K. Uptake, Concentration, and Cycle of Certain Radioisotopes in the Oyster. Unpublished Master of Science in Engineering Thesis. University of Florida, Gainesville, Fla. (January 1960).

(*8*) MURTHY, G. K., A. S. GOLDIN, and J. E. CAMPBELL. Zinc-65 in foods. Science 130:1255-1256.

Strontium-90, Cesium-137, and Polonium-210 in Human Tissues

E. J. Baratta and E. S. Ferri[1]

The concentration of strontium–90, cesium–137, and polonium–210 in various human tissues have been measured at the Northeastern Radiological Health Laboratory, Public Health Service, since 1965. The choice of organs for this study was based on the function of the organ, the type of tissue it represented, and whether it was reported that the radionuclides under study tended to concentrate in that organ. Lung was selected because of its major respiratory function and the reported increased levels of polonium–210 in this organ in smokers versus nonsmokers (*1–3*). Liver was chosen because of its major role in metabolism, heart because it represents a visceral muscle tissue, kidney because of its excretory function, and psoas muscle because it represents voluntary or striated muscle which constitutes a major portion of the body mass. Other available tissues were also examined. Although all specimens were from persons who had died of disease, the cause of death could not be considered as a parameter for interpreting the data, because the sample population from any one cause was not large enough.

A detailed discussion of the analytical procedures used and interpretation of the results appear elsewhere (*4*). Table 1 lists the levels of strontium–90, cesium–137, and polonium–210 in the various tissues.

For cesium–137, the International Commission on Radiological Protection (ICRP) model for the "standard man" predicts that for a given body burden the concentration in spleen and liver tissue would be about double that in muscle (*5*). These studies showed the greatest concentration to be in muscle and this was about twice that in the liver and spleen. For strontium–90, it appears that a substantial percentage of the total body burden is also in the muscle. For polonium–210, the ICRP model predicts a maximum concentration in the spleen and a minimum in bone (*5*). This study showed

---

[1] Mr. Baratta is director and Mrs. Ferri assistant director, Analytical Services, Northeastern Radiological Health Laboratory, National Center for Radiological Health, Public Health Service, Winchester, Mass. 01890.

Table 1. Radionuclide concentrations in adult human tissues

Tissue	Sex	Concentration ±2σ counting error (pCi/100 g wet weight)				
		Strontium-90	Cesium-137	Polonium-210	Polonium-210 (smokers)[a]	Polonium-210 (nonsmokers)
Liver	Male	[b] (6) 0.84 ±.07	(10) 22 ±3		(8) 1.5 ±.03	(3) 1.3 ±.08
	Female	(9) .73 ±.07	(13) 15 ±3		(4) 1.2 ±.04	(8) 1.0 ±.09
Kidney	Male	(7) .88 ±.10	(10) 19 ±7		(5) .8 ±.03	(2) 1.6 ±.04
	Female	(8) .46 ±.18	(13) 15 ±6		(4) .8 ±.09	(8) .6 ±.08
Heart	Male	(5) 1.39 ±.04	(10) 17 ±5		(8) .2 ±.04	(2) .1 ±.08
	Female	(7) .74 ±.10	(12) 17 ±9		(4) .4 ±.08	(8) .3 ±.04
Lung	Male	(2) .47 ±.04	(4) 16 ±3		(3) .4 ±.03	(1) .2 ±.01
	Female	(5) 1.35 ±.07	(8) 13 ±3		(3) .4 ±.02	(5) .3 ±.02
Blood	Male	(2) .25 ±.25	(10) 22 ±9		(7) .5 ±.05	(1) .3 ±.08
	Female	(8) 1.06 ±.15	(17) 19 ±10		(6) .2 ±.08	(8) .4 ±.08
Psoas muscle	Male	(4) 1.87 ±.33	(5) 40 ±14		(4) .1 ±.06	(1) .02 ±.04
	Female	(3) .19 ±.30	(5) 52 ±21		(1) .2 ±.06	(3) .1 ±.07
Spleen	Male	(3) .4 ±.15	(3) 20 ±12	(3) 0.4 ±.06		
	Female	(2) .3 ±.20	(2) 20 ±10	(2) .4 ±.97		
Stomach	Male	(1) .4 ±.09	(1) 25 ±7	(1) .3 ±.02		
	Female	NA	(1) 15 ±6	(1) .1 ±.03		
Compact and spongy bone	Male	(4) 10.4 ±.44	(4) 25 ±25	(4) 3.5 ±.19		
	Female	(8) 6.5 ±.35	(8) 30 ±25	(8) 2.9 ±.21		
Bone marrow	Male	(4) 6.6 ±.60	(4) 40 ±53	(4) 3.6 ±.20		
	Female	(4) 7.8 ±.68	(4) 40 ±60	(4) 2.1 ±.30		
Pancreas	Male	(1) 1.2 ±.49	(1) 55 ±52	(1) .4 ±.18		
Testes	Male	(2) .5 ±.34	(2) 35 ±76	(2) 1.50 ±.30		

[a] Donor smoked one or more packs per day.
[b] Figures in parentheses indicate number of samples analyzed.
NA, no analysis.

-113-

that for chronic environmental exposure, the reverse is true—that is, the maximum observed concentration is in the bone, the minimum in the spleen.

Although the data reported are of a limited nature, the differences in the observed values and those predicted by the ICRP model are readily apparent. Much of the biological data used in the ICRP model are based on acute injection exposures in animals. The inadequacies of the model predictions substantiate the call by the ICRP, the National Council on Radiation Protection and Measurements (*6*), the Federal Radiation Council (*7*), and others for greater efforts in measuring the biological parameters underlining the distribution of radionuclides in human beings.

REFERENCES

(*1*) HOLTZMAN, R. B., and F. H. ILCEWICZ. Lead-210 and polonium-210 in tissues of cigarette smokers. Science 153:1259-1260 (September 9, 1966).

(*2*) FERRI, E. S., and E. J. BARATTA. Polonium-210 in tobacco products and human tissues. Radiol Health Data Rep 7:485-488 (September 1966).

(*3*) HILL, C. R. Polonium-210 in man. Nature 208:423-428 (October 30, 1965).

(*4*) BARATTA, E. J., and E. S. FERRI. Radionuclides in selected human tissues. Amer Hyg Assoc J 27:438-443 (September-October 1966).

(*5*) INTERNATIONAL COMMISSION ON RADIATION PROTECTION. Report of ICRP Committee II on permissible dose for internal radiation (1959), with bibliography for biological, mathematical, and physical data. Health Physics 3:1-380 (June 1960).

(*6*) NATIONAL COUNCIL ON RADIATION PROTECTION AND MEASUREMENTS. Maximum permissible body burdens and maximum permissible concentrations of radionuclides in air and in water for occupational exposure, NBS Handbook 69:10-11 (June 5, 1959). Available from the Clearinghouse for Federal Scientific and Technical Information. Springfield, Va. 22151.

(*7*) FEDERAL RADIATION COUNCIL. Staff report on background material for the development of radiation protection standards, Report 1:39 (May 13, 1960).

Reported Nuclear Detonations, April 1967

During April 1967, three U.S. Nuclear tests were reported; on April 7, 21 and 27, underground nuclear tests of low yield (less than 20 kilotons TNT equivalent) were conducted by the U.S. Atomic Energy Commission at its Nevada Test Site.

On April 20, 1967, the United States recorded seismic signals which originated from the Soviet nuclear test area in the Semipalatinsk region. The signals were equivalent to those of a nuclear test in the low-intermediate yield range (20 to 200 kilotons TNT equivalent).

-114-

SYNOPSES

Synopses of reports, incorporating a list of key words, are furnished below in reference-card format for the convenience of readers who may wish to clip them for their files.

RADIATION HAZARDS FROM X-RAY DIFFRACTION EQUIPMENT. *J. R. Howley and C. Robbins. Radiological Health Data and Reports, Vol 8, May 1967, pp. 245–249.*

Improper or careless use of X-ray diffraction equipment can cause severe burns to the upper extremities of the body of the operator. These burns are slow to heal and can lead to cancer. Cataracts and other opacities can be produced in the eye with a single exposure of 200 roentgens. The use of inadequate survey equipment can lead to a gross underestimate of the hazard. Since serious injury from intense primary beam radiation can occur in a matter of seconds and the hazard from scattered radiation is also significant, the use of film badge monitoring alone can give a false sense of protection. Recommendations are given.

KEY WORDS: cancer, cataracts, film badges, radiation detectors, radiation safety, shielding, X rays, X-ray diffraction equipment.

RADIOLOGICAL HEALTH DATA AND REPORTS

Volume 8, Number 6, June 1967

In August 1959, the President directed the Secretary of Health, Education, and Welfare, to intensify Departmental activities in the field of radiological health. The Department was assigned responsibility within the Executive Branch for the collection, analysis, and interpretation of data on environmental radiation levels such as natural background, radiography, medical and industrial uses of isotopes and X rays, and fallout. The Department delegated this responsibility to the National Center for Radiological Health, Public Health Service.

Radiological Health Data and Reports, a monthly publication of the Public Health Service, includes data and reports provided to the National Center for Radiological Health by Federal agencies, State health departments, and foreign governmental agencies. Pertinent original data and interpretive manuscripts are invited from investigators.

The Federal agencies listed below appoint their representatives to a Board of Editorial Advisers. Members of the Board advise on general publications policy; secure appropriate data and manuscripts from their agencies; and review those contents which relate to the special functions of their agencies.

Department of Defense
Department of Agriculture
Department of Commerce
Department of Health, Education, and Welfare
Atomic Energy Commission

CONTENTS

REPORTS

Page

Fallout from the Third Chinese Nuclear Test May 9, 1966 301
R. D. Grundy and *D. R. Snavely*

DATA

SECTION I. MILK AND FOOD 317

National and International Milk Surveillance 318

1. Pasteurized Milk Network, February 1967, *PHS* 318
2. Canadian Milk Network, February 1967 321
3. Pan American Milk Sampling Program, February 1967, *PAHO* and *PHS* 322

State Milk Surveillance Activities 323

1. California Milk Network, October–December 1966 323
2. Oregon Milk Network, October–December 1966 325
3. Washington Milk Network, October–December 1966 326

Food and Diet Surveillance Activities 328

1. Strontium-90 in Tri-City Diets, May–June 1966, *HASL* 329

-116-

CONTENTS—continued

Page

SECTION II. WATER 331

Gross Radioactivity in Surface Waters of the United States December 1966, *FWPCA* 332

Radiostrontium in Tap Water, March–November 1966, *HASL* 334

Radioactivity in California Waters, January–June 1966 335

SECTION III. AIR AND DEPOSITION 339

Radioactivity in Airborne Particulates and Precipitation 339

1. Radiation Surveillance Network, February 1967, *PHS* 340
2. Canadian Air and Precipitation Monitoring Program, February 1967 343
3. Mexican Air Monitoring Program, February 1967 344
4. Pan American Air Sampling Program, February 1967, *PAHO* and *PHS* 345

SECTION IV. OTHER DATA 347

Environmental Levels of Radioactivity at Atomic Energy Commission Installations 347

1. Brookhaven National Laboratory, July–December and annual Summary 1966 347
2. Lawrence Radiation Laboratory, January–June 1966 349

SECTION V. TECHNICAL NOTES 353

Status of Full Scale Strontium-90 Removal System for Fluid Milk, *NCRH* 353

Reported Nuclear Detonations, May 1967 354

Synopses iii

Symbols, Units, and Equivalents .... Inside back cover

RADIOLOGICAL HEALTH DATA AND REPORTS

Published under the direction of

James G. Terrill, Jr., Director and
Dr. Raymond T. Moore, Deputy Director
National Center for Radiological Health

by the Standards and Intelligence Branch
National Center for Radiological Health
Donald L. Snow, Chief

BOARD OF EDITORIAL ADVISORS

Dr. Hugh B. Mitchell
Department of Defense
Dr. Ronald G. Menzel
Department of Agriculture
Dr. Wilfrid B. Mann
Department of Commerce
Robert E. Simpson
Food & Drug Administration, DHEW
John A. Harris
Atomic Energy Commission

STAFF

Managing Editor
Samuel Wieder
Assistant Managing Editor
Charles F. Coyle
Senior Technical Editor
Marvin Rosenstein
Technical Editors
Kurt L. Feldmann
Richard Wromble
Illustrator
Marylee Hill

Address correspondence to the Managing Editor, *Radiological Health Data and Reports*, National Center for Radiological Health, Public Health Service, Rockville, Maryland 20852.

For subscriptions to *Radiological Health Data and Reports*, please use the order form on last page of this issue.

U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service ● National Center for Radiological Health

Fallout from the Third Chinese Nuclear Test—May 9, 1966

R. D. Grundy [1] *and D. R. Snavely* [2]

Fresh fission product debris was detected in the United States in several environmental media following the third Chinese atmospheric nuclear detonation of May 9, 1966. Peak concentrations in air, precipitation, deposition, bovine thyroids, and milk, occurred in the Central and Southern States. Levels of iodine-131 in milk as observed by 4 State sampling programs and 18 U.S. Public Health Service Pasteurized Milk Network stations provided the basis for calculating iodine-131 pasture weathering half-times of 4 to 16 days. A peak iodine-131 milk concentration of [illegible] pCi/liter was observed in Arkansas on May 21, 1966. The resultant cumulative iodine-131 intake at this location based upon an assumed daily milk consumption of 1 liter, was calculated to correspond to 1.7 percent of the Protective Action Guide as established by the Federal Radiation Council.

Summary of surveillance data

On May 9, 1966, a third nuclear detonation occurred on the mainland of China (*1*). The test was believed to have taken place in northwest China and was equal to or greater in total yield, expressed as an equivalent force of TNT, than the earlier two detonations (October 16, 1964 (*2*) and May 14, 1965 (*3*)). Subsequent to this test, fresh fission products were observed in the United States [3] by Federal and State environmental monitoring systems. This report summarizes the extent and magnitude of the intrusion of fresh fission products into the environment during May and June 1966, as indicated by State milk sampling systems and the Radiation Surveillance Network (*4–7*), Pasteurized Milk Network (*8–9*), and the Bovine Thyroid Network (*10*) of the U.S. Public Health Service.

Intrusion pattern

In all but 6 cases out of 74 the April 1966 maximum daily gross beta radioactivity concentration for a station was less than twice the monthly average. The April 1966 averages (*11*) ranged from 0.10 to 0.26 pCi/m³ (except for Cheyenne, Wyo., which was 0.76 pCi/m³).

In view of the relatively constant concentrations of beta radioactivity in air that existed immediately prior to the detonation, it was assumed that the presence of fresh fission products at a given Radiation Surveillance Network (RSN) station was indicated by a daily air gross beta radioactivity concentration greater than twice the previous month's (April 1966) average for that station (*11*).

On the above basis, fresh fission products were first detected in surface air at two RSN stations on samples collected May 13–14, 1966, (approximately 5 days after the detonation). The stations were Denver, Colo., and Boise, Idaho, and the gross beta radioactivity concentrations were 3.3 and 2.4 pCi/m³, respectively.

Immediately preceding this detonation all precipitation samples showed gross beta radioactivity concentrations less than 200 pCi/liter. Similarly, precipitation samples with gross beta radioactivity concentrations greater than 200 pCi/liter were considered indicative of the presence of fresh fission products.

---

[1] Mr. Grundy was formerly chief, Data Analysis and Operations Section, Standards and Intelligence Branch, NCRH, Washington, D.C.

[2] Mr. Snavely is operations officer, Data Analysis and Operations Section, Standards and Intelligence Branch, NCRH, Washington, D.C.

[3] Defined in this report as the original 48 States.

Using the results of the air and precipitation measurements, it was possible to approximate the intrusion pattern of fresh fission product debris in surface air across the United States. The indicated pattern (figure 1) is only a general approximation of what occurred, and is not intended to define the extent of lateral spread of the debris cloud, since uncertainties in the data are too great for anything but general approximations. The indicated dates represent a 24-hour collection period from 8 a.m. the first day to 8 a.m. the following day.

Following the initial appearance of fresh fission products on May 13–14, the debris cloud proceeded across the Western Plain States on May 14–15, centered over the Midwest on May 15–16, and passed over the South and East on May 16–17. In this period (May and June 1966) the maximum RSN air gross beta radioactivity concentration was 14.9 pCi/m³ at Phoenix, Ariz., on May 19–20, 1966.

It should be noted that all RSN air gross beta radioactivity concentrations greater than 10 pCi/m³ (six samples) occurred in the West and Southwest between May 14 and 26, 1966. In general, these activities occurred 5 to 6 days after the passage of the leading edge of the surface air debris cloud. This time lag is comparable with results observed for the second Chinese mainland test (*12*).

Air

An effort was made to evaluate the extent and magnitude of the intrusion of fresh fission product debris. It was shown that as the peak air gross beta radioactivity concentrations increased with time, the percent of the RSN stations showing concentrations greater than 1.0 pCi/m³ increased. The relative magnitude of the intrusion was then evaluated on a regional basis in terms of the percentage of RSN stations with gross beta radioactivity concentrations in air greater than 1.0 pCi/m³.

Regional grouping of the data on a semiweekly basis (Sunday through Wednesday and Thursday through Saturday) are given in table 1. A maximum of 80 percent was observed in Region VIII for the period May 26 through May

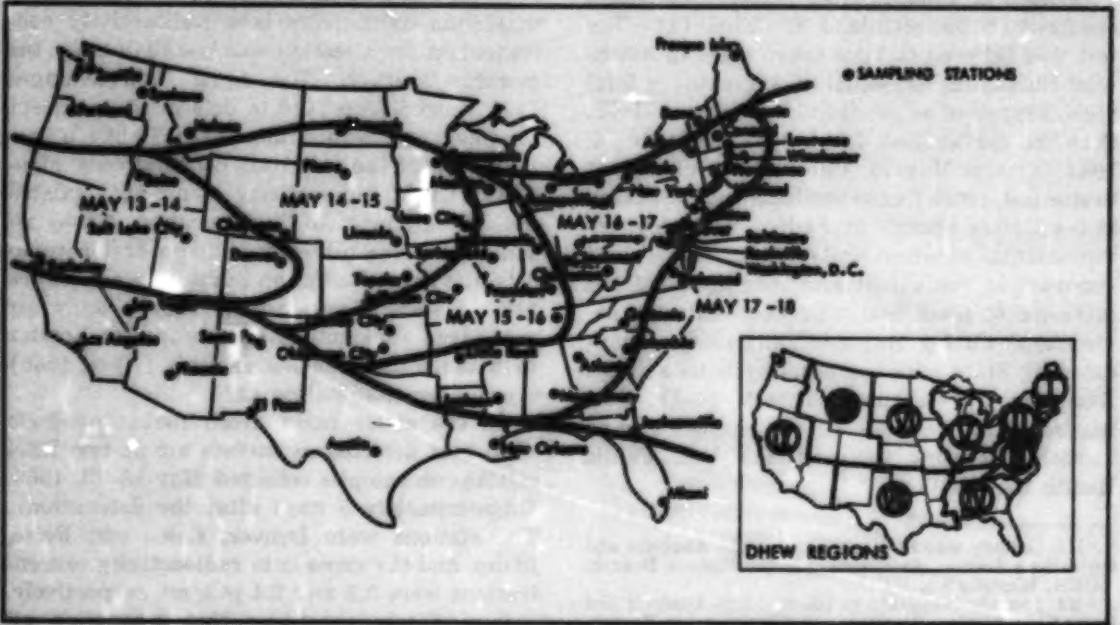

Presque Isle
● SAMPLING STATIONS
Seattle
Spokane
Portland
Helena
Boise
MAY 13 -14
Salt Lake City
Cheyenne
Denver
MAY 14 -15
Pierre
Lincoln
Iowa City
Topeka
Kansas City
Oklahoma City
Little Rock
MAY 15 -16
MAY 16 -17
New York
Lawrence
Winchester
Baltimore
Rockville
Washington, D.C.
MAY 17 -18
Atlanta
Jacksonville
New Orleans
Miami
Austin
El Paso
Phoenix
Santa Fe
Las Vegas
Los Angeles
DHEW REGIONS

Figure 1. Approximate intrusion pattern of the fresh fission product debris cloud across the United States from the third Chinese nuclear detonation as indicated by the RSN

Table 1. Percentage of daily RSN air filters with gross beta radioactivity greater than 1 pCi/m³

Region *	May 1966							June 1966							
	8–11	12–14	15–18	19–21	22–25	26–28	29–1	2–4	5–8	9–11	12–15	16–18	19–22	23–25	26–29
Region I	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Region II	0	0	0	5	0	17	0	0	0	0	0	0	0	0	0
Region III	0	0	6	10	11	33	0	0	0	0	0	0	0	0	0
Region IV	0	0	6	42	55	17	17	0	4	0	0	0	0	0	0
Region V	0	0	14	10	11	0	0	0	0	0	3	0	0	0	0
Region VI	0	0	11	10	19	0	0	0	0	5	0	0	0	0	0
Region VII	0	0	7	48	62	19	14	5	23	4	0	0	4	0	0
Region VIII	0	12	10	47	25	60	37	47	20	20	0	0	0	0	0
Region IX	0	0	0	28	29	48	21	15	0	5	0	0	0	0	0
Alaska	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hawaii	0	0	0	0	75	33	0	0	0	0	0	0	0	0	0

* For identification of States within Region, see insert, figure 1.

23. These data indicate that the extent and relative magnitude of the intrusion of fresh fission products were greatest in Regions IV, VII, VIII, and IX. These regions represent the Southern, South Central, Western and Far Western United States, respectively.

Precipitation

Gross beta radioactivity concentrations in RSN precipitation samples were observed to increase sharply during the latter part of May 1966. Prior to this time (April 1966), precipitation activities were, in general, below the minimum detectable concentration of 200 pCi/liter (*11*). An effort was made to evaluate the geographic extent of the deposition of fission product debris by precipitation in terms of the percentage of the precipitation samples exhibiting gross beta radioactivity concentrations greater than 200 pCi/liter. These data are given in table 2. The regional grouping of the data on a semiweekly basis indicates that the extent of the deposition of fresh fission product debris by precipitation was greatest in the Far Western, Western and Southern United States.

The magnitude of deposition resulting from precipitation was evaluated on the basis of RSN results (*4–7*). Depositions of gross beta radioactivity greater than 10 nCi/m² are summarized on a semiweekly basis in table 3. From the isograms of total gross beta radioactivity depositions from May 15 to 28 (figure 2), it is readily apparent that the Central United States received the greatest depositions. From table 3, it is seen that these occurred between May 15 and 25, immediately following the passage of the debris cloud across this area as indicated by the RSN surface air measurements (figure 1).

Table 2. Percentage of RSN precipitation samples with gross beta radioactivity greater than 200 pCi/liter

Region *	May 1966							June 1966							
	8–11	12–14	15–18	19–21	22–25	26–28	29–1	2–4	5–8	9–11	12–15	16–18	19–22	23–25	26–29
Region I	12	0	0	38	75	25	0	80	71	30	33	25	50	20	46
Region II	0	0	0	75	50	100	60	NS	100	33	0	0	33	NS	0
Region III	0	0	25	100	80	67	63	NS	80	43	0	17	0	NS	20
Region IV	0	0	73	100	86	100	83	0	40	25	33	0	0	33	60
Region V	0	0	88	100	80	NS	100	0	60	17	75	0	NS	NS	20
Region VI	11	0	96	90	100	NS	100	100	90	36	50	75	100	0	25
Region VII	0	0	55	40	100	0	100	100	100	NS	73	17	60	0	14
Region VIII	0	0	0	NS	NS	NS	100	100	75	67	NS	75	100	80	100
Region IX	0	0	0	NS	0	50	100	75	50	33	0	NS	NS	25	33
Alaska	0	0	0	0	0	0	33	0	NS	NS	0	0	0	NS	0
Hawaii	NS	NS	NS	0	NS	NS	0	NS	NS	NS	NS	NS	NS	NS	NS

* For identification of States within Region, see insert, figure 1.
NS, no sample collected.

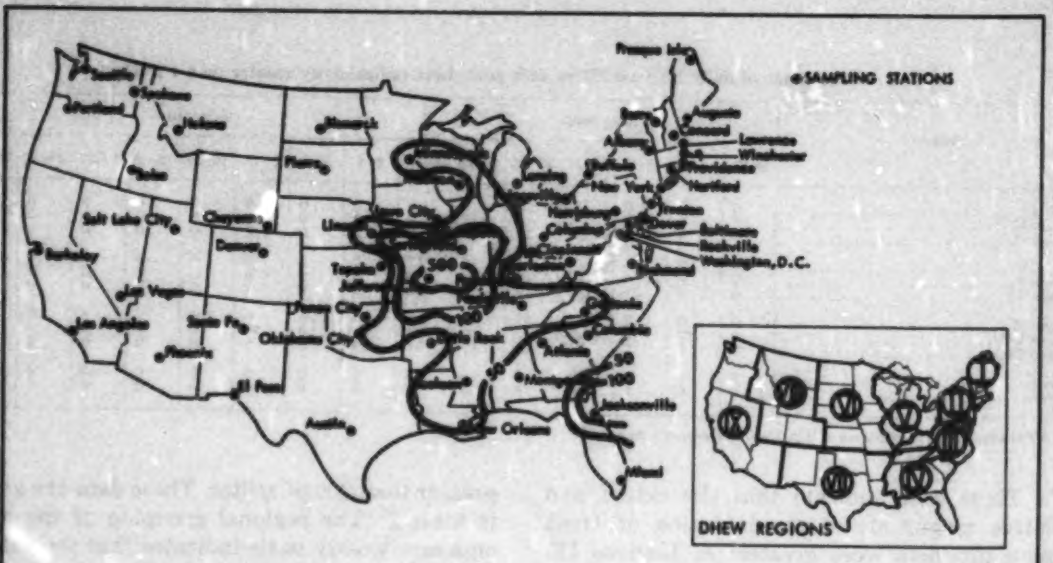

SAMPLING STATIONS
Presque Isle
Seattle
Spokane
Portland
Helena
Bismarck
Boise
Pierre
Salt Lake City
Cheyenne
Denver
Berkeley
Las Vegas
Los Angeles
Santa Fe
Phoenix
El Paso
Austin
Oklahoma City
Topeka
Lincoln
Iowa City
Little Rock
New Orleans
Montgomery
Jacksonville
Miami
Atlanta
Columbia
Lansing
Buffalo
New York
Harrisburg
Columbus
Trenton
Dover
Baltimore
Rockville
Washington, D.C.
Richmond
Albany
Augusta
Concord
Lawrence
Winchester
Providence
Hartford
500
100
50
100
DHEW REGIONS
I
II
III
IV
V
VI
VII
VIII
IX

Figure 2. Total deposition of gross beta radioactivity in nCi/m² as observed in RSN precipitation samples (May 15 through May 28, 1966)

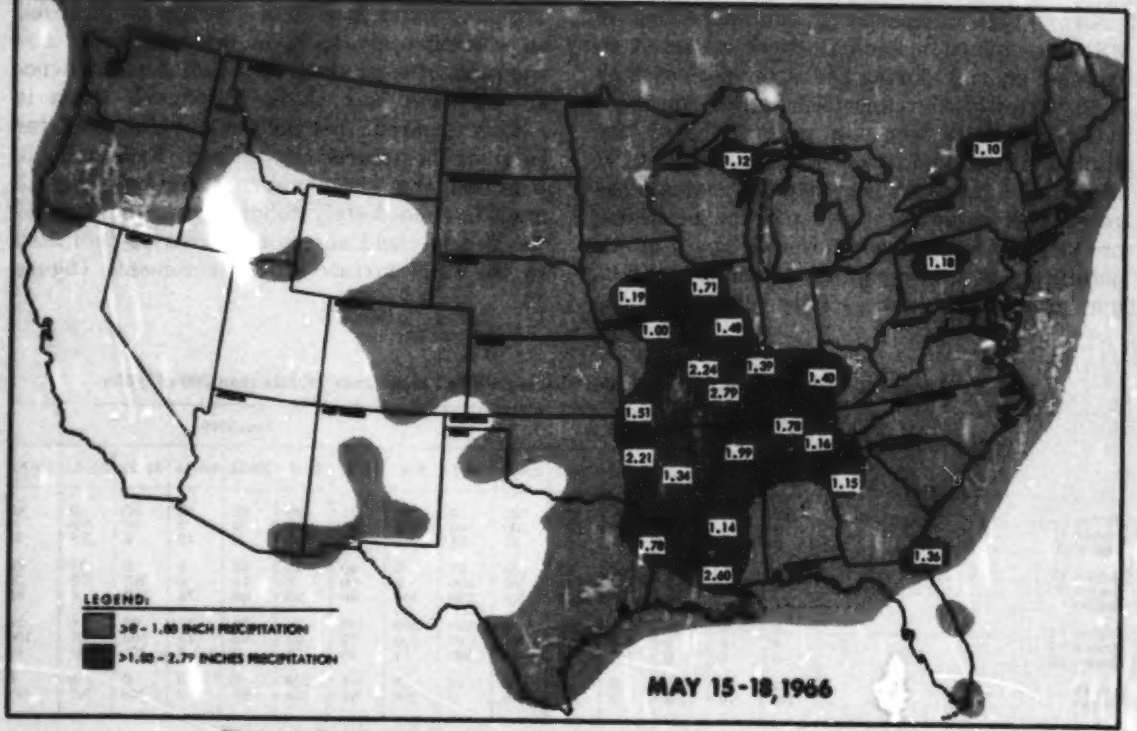

1.12
1.10
1.18
1.19
1.71
1.00
1.48
2.24
1.39
1.40
2.79
1.51
1.78
1.16
2.21
1.99
1.34
1.15
1.14
1.78
1.36
2.60
LEGEND:
>0 - 1.00 INCH PRECIPITATION
>1.00 - 2.79 INCHES PRECIPITATION
MAY 15-18, 1966

Figure 3. Total precipitation occurring between May 15 and 18, 1966 (18)

-121-

Table 3. Semiweekly wet deposition of gross beta radioactivity greater than 10 nCi/m²

Region and States	Deposition (nCi/m²)														
	May 1966							June 1966							
	9–11	12–14	15–18	19–21	22–25	26–28	29–1	2–4	5–8	9–11	12–15	16–18	19–22	23–25	26–29
Region I															
Maine				86.2											
Region II															
Region III															
District of Columbia				13.5											
Kentucky			41.7												
North Carolina			61.5												
Region IV															
Alabama															13.1
Florida:															
Jacksonville			30.0	10.1	151	10.9				13.6			13.9		
Miami					27.3		16.3		12.5						
Mississippi				28.0	29.6										
South Carolina					16.4					14.0			17.0		
Tennessee			72.5												
Region V															
Illinois			250												
Indiana			109												
Michigan			11.1							10.1					
Ohio: Columbus					13.9										
Wisconsin					36.4										
Region VI															
Iowa			11.2		13.7				13.1						
Kansas											21.5				
Minnesota					57.5			17.0							
Missouri			450	15.6	36.8										9.
Nebraska				33.5	57.1										
North Dakota														11.4	
Region VII															
Louisiana				47.7											
Oklahoma:															
Oklahoma City				50.7											
Ponca City			12.9												
Region VIII															
Wyoming									30.6						
Region IX															

Additional isolated cases of deposition, approaching the levels observed in the Midwest, occurred in Augusta, Maine; Gastonia, N.C.; and Jacksonville, Fla.

Comparison of gross beta radioactivity deposition with total rainfall measurements obtained from the Weather Bureau (*13*) for the period of May 15 through 25, 1966, show good correlation. For the period of May 15 through 18, rainfalls were greatest in the Mississippi Valley States (figure 3), which coincides with the areas of greatest radioactivity deposition. Similar correlations are observed between rainfall and total deposition for the periods of May 19 through 21 (figure 4), and May 22 through 25 (figure 5).

The RSN gross beta radioactivity measurements of air, precipitation and total wet deposition have provided a basis for evaluating the extent and magnitude of the intrusion of fresh fission products into the environment. While the first indication of fresh fission product debris was observed by the RSN air and precipitation measurements, evidence of iodine–131 entrance into the food chain of man was reflected in bovine thyroids collected by the Bovine Thyroid Network (BTN), and in milk collected by the Pasteurized Milk Network (PMN).

Bovine thyroids

During May and June 1966, iodine–131 was found in bovine thyroids in measurable quantities at all collection areas (*10*). Although the collection areas were not uniformly distributed throughout the United States, analysis of

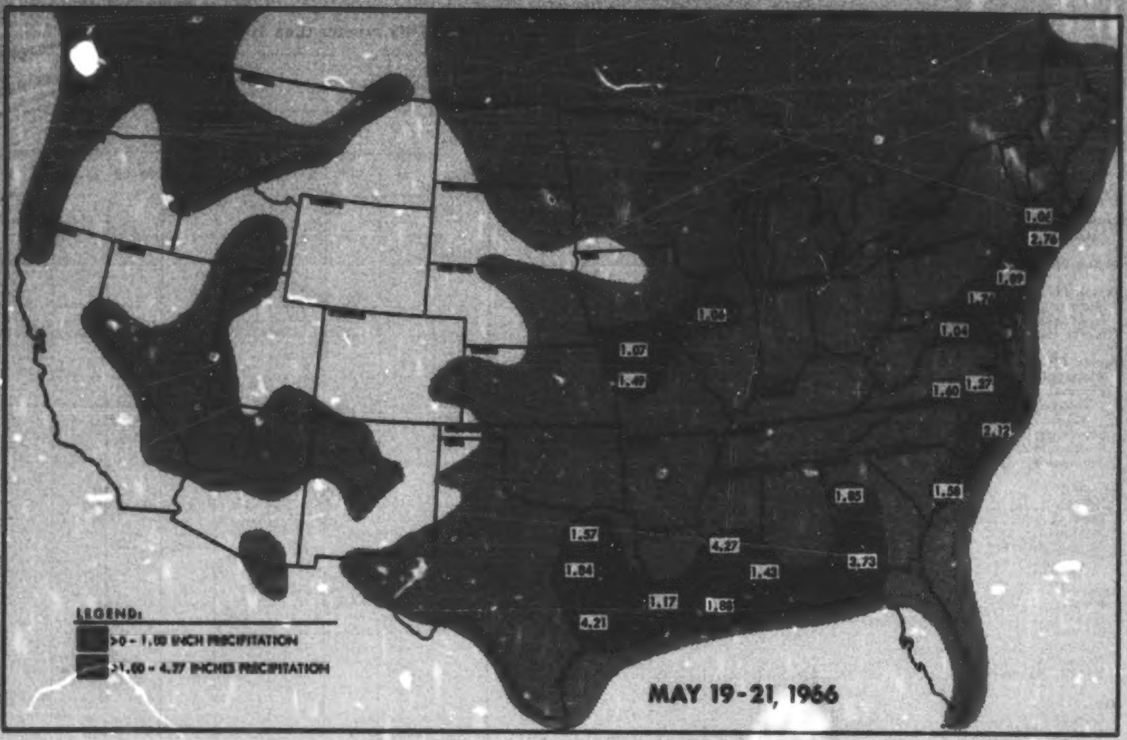


Figure 4. Total precipitation occurring between May 19 and 21, 1966 (*13*)

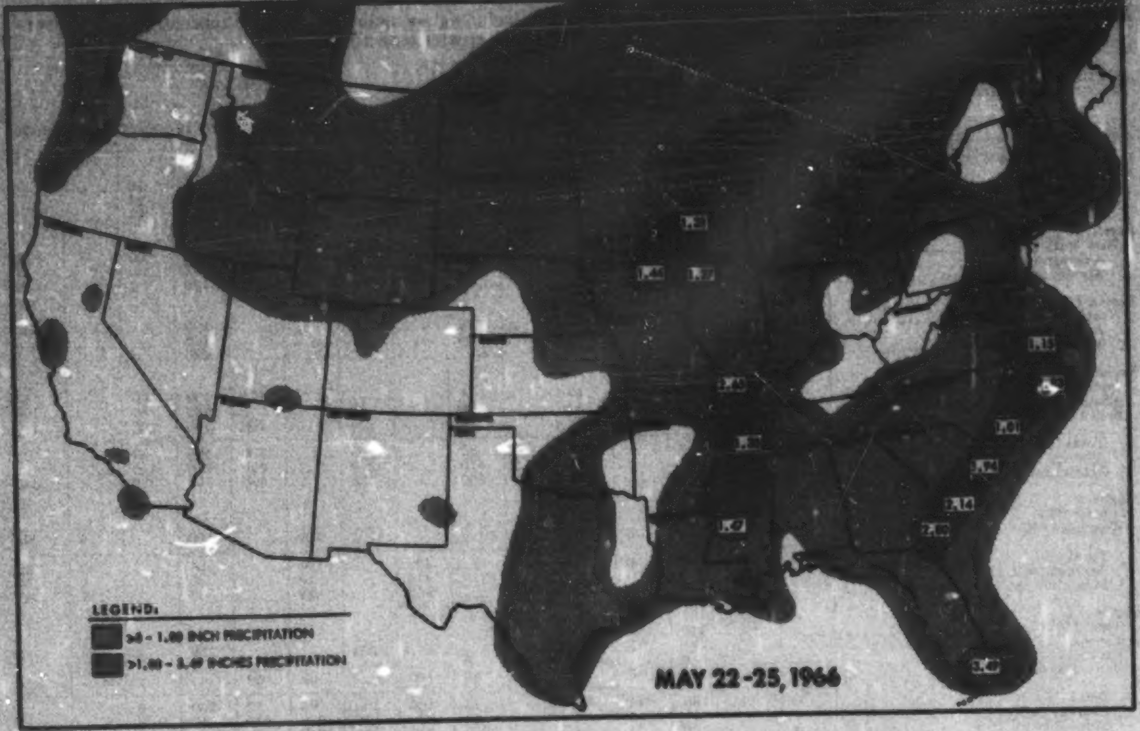
bovine thyroids served as an extremely sensitive method for the detection of iodine–131. While not as quick in its response as the determination of gross beta radioactivity levels in surface air, the BTN is specific for this radionuclide. It should be noted that although the thyroid sampling areas overlap the milksheds serving the metropolitan areas participating in the Pasteurized Milk Network (*12*) the selection of thyroid collection locations was based upon proximity to major nuclear reactors, spent-fuel reprocessing plants, and nuclear testing sites, not major population groups.

Because of the relatively small number of thyroids collected on any one day in a single area, it is difficult to relate the levels of iodine–131 in the bovine thyroid to the changing radioactivity levels in other environmental media. However, when the data were grouped on a regional basis, general trends for the influx of iodine–131 into the environment were seen.

Efforts were made to evaluate the extent of iodine–131 intrusion into the environment in terms of bovine thyroid results by grouping samples on a semiweekly basis. The percentages of samples exhibiting iodine–131 concentrations greater than 10 pCi/g of thyroid were then determined (table 4). Although the number of samples is limited, generally the findings show a geographical distribution similar to those observed for RSN air and deposition results (see tables 1, 3, and 4).

The magnitude of the intrusion can only be determined in a relative manner since for the areas receiving the highest fallout deposition (figure 2), the number of samples was small. The highest individual thyroid iodine–131 concentrations were 880 pCi/g on June 1 in Mississippi, and 880 pCi/g on June 7 in Colorado. The maximum semiweekly average was 530 pCi/g for June 5 through 8 in Region VII (New Mexico).

- 123 -



LEGEND:
>0 - 1.00 INCH PRECIPITATION
>1.00 - 3.49 INCHES PRECIPITATION
MAY 22-25, 1966

Figure 5. Total precipitation occurring between May 22 and 25, 1966 (12)

In the geographical area where gross beta radioactivity deposition was greater than 100 nCi/m^2 (figure 2), the number of bovine thyroid samples collected for this period (May and June 1966) was small. However, results from Region IV (Georgia, Mississippi, and South Carolina) indicated a sharp rise in iodine–131 activity around May 20 (figure 6), that reached a maximum semiweekly average of 400 pCi/g, followed by decay characteristic of a single deposition event. Similar results were observed (table 4) for Region VII (New Mexico).

Although data on the levels of iodine–131 in bovine thyroids were limited, it is evident that an increase in air radioactivity preceded the detection of iodine–131 in the thyroids, with both media clearly delineating the intrusion.

Milk

Following the third Chinese atmospheric nuclear test, the PHS Pasteurized Milk Network (PMN), and 31 State milk sampling networks (table 5), monitored iodine–131 concentrations in milk at an increased sampling frequency. For the period of May and June 1966, the sampling frequency for the PMN was increased to twice a week so as to provide greater coverage. The first appearance of iodine–131 in milk (20 pCi/liter or greater) occurred in those samples collected between May 15 and 18, at four locations. On May 16, iodine–131 in milk was reported by the State of Iowa at a concentration of 20 pCi/liter; however, it was not reported as present (greater than 10 pCi/liter) in a PMN sample collected on May 16 at Iowa City. The second appearance of iodine–131 in milk

Table 4. Iodine-131 in bovine thyroid samples May 9–June 29, 1966 (including maximum and average concentrations, and percent of samples with iodine-131 concentrations greater than 10 pCi/g)

Region and States [a]	May 1966							June 1966							
	9–11	12–14	15–18	19–21	22–25	26–28	29–1	2–4	5–8	9–11	12–15	16–18	19–22	23–25	26–29
Region I															
Vermont (%)	0	------	0	0	33	------	8	------	50	------	0	------	70	------	0
Average (pCi/g)	1	------	0	0	11	------	0	------	[illegible]	------	0	------	23	------	[illegible]
Maximum (pCi/g)	1	------	0	------	48	------	1	------	150	------	8	------	64	------	0
Region II															
New York (%)	------	0	0	0	20	------	------	43	30	71	67	77	90	73	[illegible]
Average (pCi/g)	------	0	1	0	66	------	------	[illegible]	25	28	54	41	30	28	[illegible]
Maximum (pCi/g)	------	1	2	2	200	------	------	130	96	67	120	130	88	46	[illegible]
Region III															
North Carolina (%)	------	------	25	------	------	------	100	------	------	------	------	100	------	------	------
Average (pCi/g)	------	------	6	------	------	------	46	------	------	------	------	123	------	------	------
Maximum (pCi/g)	------	------	11	------	------	------	------	------	------	------	------	260	------	------	------
Region IV															
Georgia (%)	0	------	0	------	40	------	71	------	------	------	100	100	100	------	92
Mississippi (%)	0	------	0	------	33	------	100	------	100	------	------	100	80	------	100
South Carolina (%)	0	------	------	------	80	------	100	------	------	------	100	100	100	------	100
Total (%)	0	------	0	------	50	------	93	------	100	------	100	100	96	------	96
Average (pCi/g)	1	------	0	------	42	------	410	------	210	------	240	210	110	------	91
Maximum (pCi/g)	2	------	1	------	150	------	880	------	330	------	890	700	280	------	[illegible]
Region V															
Illinois (%)	------	------	------	------	------	------	------	100	------	------	------	------	------	------	------
Wisconsin (%)	------	0	0	0	------	71	------	------	------	100	------	100	------	50	80
Total (%)	------	0	0	0	------	71	------	100	------	100	------	100	------	50	80
Average (pCi/g)	------	0	0	4	------	68	------	410	------	10	------	49	------	9	25
Maximum (pCi/g)	------	0	0	6	------	300	------	880	------	24	------	53	------	12	48
Region VI															
Iowa (%)	------	------	100	------	------	------	------	------	------	------	------	------	------	------	------
Kansas (%)	------	------	------	33	0	------	------	------	100	------	------	100	0	------	------
Minnesota (%)	------	------	0	------	------	------	0	------	------	------	------	------	------	------	------
South Dakota (%)	0	------	0	0	25	------	60	100	------	83	83	------	------	------	------
Total (%)	0	------	33	14	20	------	43	100	100	83	83	100	0	------	------
Average (pCi/g)	2	------	11	5	5	------	63	170	210	240	450	40	9	------	------
Maximum (pCi/g)	4	------	20	21	11	------	260	280	210	640	814	40	9	------	------
Region VII															
Arkansas (%)	------	0	------	------	------	------	------	------	------	------	------	------	------	------	------
New Mexico (%)	13	------	38	------	100	------	100	------	100	------	100	88	75	------	------
Oklahoma (%)	0	0	------	------	------	------	------	------	------	------	------	------	------	------	------
Texas (%)	0	------	------	------	------	------	------	------	------	------	------	------	------	------	------
Total (%)	7	0	38	------	100	------	100	------	100	------	100	88	75	------	------
Average (pCi/g)	6	3	8	------	17	------	200	------	530	------	510	100	30	------	------
Maximum (pCi/g)	17	7	15	------	25	------	250	------	760	------	790	210	97	------	------
Region VIII															
Colorado (%)	------	------	------	------	75	------	50	------	100	------	------	------	0	------	------
Idaho (%)	------	------	------	------	------	0	------	------	0	100	100	100	83	------	------
Utah (%)	------	------	------	------	------	67	40	------	50	------	75	------	------	80	25
Total (%)	------	------	------	------	75	60	44	------	67	100	78	100	71	80	25
Average (pCi/g)	------	------	------	------	29	63	61	------	220	37	78	95	55	35	21
Maximum (pCi/g)	------	------	------	------	55	460	330	------	880	80	240	120	100	74	55
Region IX															
California (%)	0	0	17	0	33	0	14	0	7	50	33	50	44	0	22
Washington (%)	------	------	------	------	------	------	25	------	63	------	------	------	------	------	------
Total (%)	0	0	17	0	33	0	19	0	33	50	33	50	44	0	22
Average (pCi/g)	1	0	8	8	11	6	11	2	16	9	8	10	23	4	11
Maximum (pCi/g)	2	1	17	6	54	9	95	3	93	17	25	24	110	9	44

[a] For identification of States within Region, see insert, figure 1.

was observed by the State of Arkansas on May 17 with a concentration of 180 pCi/liter. Although one must consider variations in the delay between milking and sample collection, a PMN sample collected 1 day earlier (May 16) showed less than 10 pCi/liter. Iodine-131 was first detected in Kentucky by the PMN on May 18 in two samples with concentrations of 20 and 30 pCi/liter. Apparent differences in the initial appearance of iodine-131 in milk between the PMN and State programs may be attributed in part to variations in sampling procedures, especially geographical and time factors. Variations due to feeding practices are assumed to be minimal for this period when dairy cattle can be expected to be on pasture

-125-

Table 5. Number of milk samples collected by States and the PMN, and minimum detectable activities

Network	Minimum detectable activities iodine-131 (pCi/liter)	Number of samples collected						
		May 15–21	May 22–28	May 29–June 4	June 5–11	June 12–18	June 19–25	Total
Alabama	10							NA
Arkansas	7	17	24	13	10	3		67
California	3	8	17	13	1			39
Colorado	10	13			2	1	1	17
Connecticut	8	2	2	2	3	2	2	13
Florida	20	2	3	3	4	5	2	19
Hawaii								NS
Idaho	50	1	1	1	1	1	1	6
Indiana	5	5	7	7	5	5	5	34
Iowa	5	6	6	4	3	2	2	21
Kansas	10		4	3	3	2	2	14
Kentucky								NS
Louisiana	10	4	2	1				7
Maine	5	1	1					2
Massachusetts								NS
Michigan	14	8	9	7	9	6	8	47
Minnesota	10	4	9		7	1	1	22
Nebraska	10	2	1		1		1	5
New Hampshire								NS
New Jersey	5	2	2	2	2	3	2	13
New York	20	7	7	7	7	7	7	42
North Dakota	10	6	6	5	6	5	6	34
Oklahoma	3	6	6	7	6	6	7	38
Oregon	15	4	3	10	2	2	2	23
Pennsylvania	10	7	7	9	8	6	7	44
Tennessee	5	6	6	6	6	6	6	36
Texas	10	4	13	9	10	9	5	50
Utah	10	28	55	25	1	1		110
Vermont	30	1	3	4	3	2	5	18
Washington	10	5	3	3	7			18
Wisconsin	10	7	13	10	12	12	11	65
State total		156	210	149	117	86	83	800
PMN	10	111	115	114	114	116	105	675
Total		266	325	263	231	202	188	1,475

NA, no analysis.
NS, no sample collected.

(*14*). Exceptions are Arizona and New Mexico where cattle are on dry-lot feeding, and California where cattle are on pasture and stored roughage (*14*).

The initial appearance of iodine–131 in milk lagged behind the cloud passage (figure 1) by approximately 2 days. The highest measured concentrations of iodine–131 in milk were found in the PMN samples collected between May 22 and 25 in the Midwest (figure 7 and table 6). A PMN sample was not collected in Arkansas on May 21 but a maximum concentration was observed by the Arkansas State Health Department for a milk sample collected in Sebastian County. The PMN sample collected closest to this maximum was that for May 24 with an iodine–131 concentration 41 percent of the State maximum, emphasizing the advantage of complementary data from Federal and State milk surveillance programs. Where the PMN provides the basis for determining geographical areas affected, the State program may furnish the detail required to determine maximum concentrations.

The relationship between the occurrence of iodine–131 in milk and bovine thyroids is seen in the graph for Region IV (figure 6). The concentrations of iodine–131 in milk follow the trend of the bovine thyroid levels.

Combining the results of the PMN and 29 State networks, the percentages of samples with iodine–131 activities greater than 20 pCi/liter were calculated on a regional basis for semiweekly intervals. A level of 20 pCi/liter was chosen in order to allow the use of results from 29 States. The results for the States of Idaho and Vermont were excluded from the calculations because their minimum detectable levels

–126

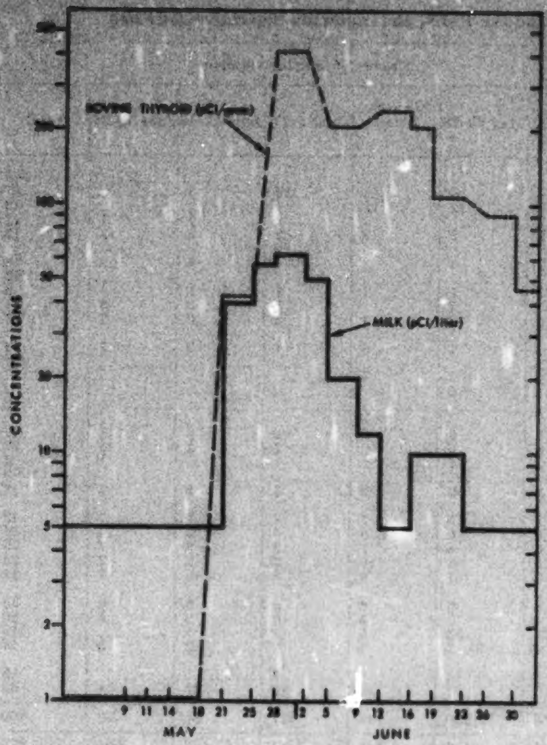


Figure 6. Average iodine-131 concentrations in bovine thyroids and milk for region IV (Georgia, Mississippi, and South Carolina) from May 9 through June 30, 1966

of iodine-131 in milk were greater than 20 pCi/liter. However, intrusion of iodine-131 into these States was minimal and exclusion of these data does not limit this evaluation. From the iodine-131 sample percentages greater than 20 pCi/liter (table 6), it is readily apparent that Regions III through VII exhibited the greatest intrusions. This is in agreement with the isograms of iodine-131 concentrations in PMN samples (figure 7) and total gross beta radioactivity deposition isograms (figure 2).

Determination of pasture half-time and intake

Because of the large number of milk samples collected through State and PHS programs, it was considered reasonable to estimate iodine-131 pasture half-times and deposition dates. According to the empirical equation developed by Lengemann (*15*), the ratio of the amount of radioiodine as a function of time, in a liter of milk corrected for radioactive decay to a constant daily radioiodine intake by the cow is given by the equation:

$$F(t) = (0.0091)(e^{0.0231t})(1 - e^{-0.293t}) \qquad (1)$$

where

F(t) = fraction of constant intake of radioiodine per liter of milk as a function of time, and

t = time after start of radioiodine intake (days).

Table 6. Percentages of milk samples collected with iodine-131 concentrations greater than 20 pCi/liter and maximum concentrations

Region [a] and State	May 1966							June 1966							
	8–11	12–14	15–18	19–21	22–25	26–28	29–1	2–4	5–8	9–11	12–15	16–18	19–22	23–25	26–30
Region I (Percent)	0	0	0	0	29	13	14	17	0	0	0	0	0	0	0
Maximum (pCi/liter)	<10	<10	< 20	< 20	20	20	20	20	< 10	<10	11	<10	<10	<10	<10
Region II (Percent)	0	0	0	0	19	17	17	21	0	7	0	97	6	0	0
Maximum (pCi/liter)	<20	<20	< 20	< 20	< 20	20	40	30	< 20	24	<20	24	32	<20	<20
Region III (Percent)	0	0	17	20	100	100	100	67	17	17	33	0	0	20	0
Maximum (pCi/liter)	<10	<10	30	30	60	60	50	40	30	20	20	<10	<10	30	<10
Region IV (Percent)	0	0	11	20	83	83	100	100	42	36	7	18	18	-----	0
Maximum (pCi/liter)	<10	<10	20	38	110	100	92	60	32	23	<20	20	20	10	<20
Region V (Percent)	0	0	0	40	44	94	63	50	27	45	32	40	0	13	0
Maximum (pCi/liter)	<10	<10	< 14	100	270	190	100	70	40	30	40	42	17	56	<14
Region VI (Percent)	0	0	7	11	82	73	67	70	65	78	67	67	18	13	0
Maximum (pCi/liter)	<10	<10	20	80	632	180	184	120	191	50	60	40	20	50	14
Region VII (Percent)	0	0	6	10	81	78	88	87	69	58	45	14	6	14	0
Maximum (pCi/liter)	<10	<10	159	922	810	490	254	118	93	77	66	20	20	20	10
Region VIII (Percent)	0	0	0	0	46	21	29	13	14	20	14	33	0	0	0
Maximum (pCi/liter)	<10	<10	15	14	269	84	136	167	20	30	20	20	<10	<10	<10
Region IX (Percent)	0	0	0	0	0	27	15	7	30	0	0	20	0	0	0
Maximum (pCi/liter)	<10	<10	< 10	< 10	< 10	30	20	40	20	<10	<10	20	<10	<10	<10
Alaska (Percent)	0	0	0	0	100	0	0	0	0	-----	-----	0	0	-----	0
Hawaii (Percent)	0	0	100	0	0	-----	0	0	0	0	0	0	0	0	0

[a] For identification of States within Region, see insert, figure 1.

-127-

This equation describes, for a constant radioiodine intake, the time relationship of radioiodine found per liter of milk if no radioactive decay occurs. Equation (1) was developed from data taken over a period of 14 days, at which time the ratio was still increasing. For periods greater than 14 days, equation (1) describes an increasing exponential function which doubles approximately every 33 days. If equilibrium conditions are actually reached in the cow at 14 days, then the iodine–131 concentration in milk would be overestimated by 48 percent at 30 days. However, since Lengemann has stated that observed radioiodine levels were still increasing after 2 weeks, the error can be assumed to be less than 48 percent.

Lengemann has suggested that the milk radioiodine concentration as a function of time be expressed as,

$$C(t) = I_o \cdot R \cdot L \cdot F(t), \qquad (2)$$

where,

I_o = first day's intake of radioiodine by an average cow,

R = factor representing radioactive decay between time of radioiodine intake and time of milking, and

L = factor to account for loss of radioiodine from grass due to physical and chemical actions of the environment.

This report concerns itself with the iodine–131 concentration in milk at the time of milking. Therefore, it was not necessary to account for the loss of radioiodine due to physical decay during the period from milk production to consumption or the volume of milk consumed daily, which were also factors suggested by Lengemann.

When the appropriate factors are substituted into equation (2) the following equation describing iodine–131 concentration in milk as a function of time was obtained:

$$C(t) = I_o(e^{-0.086t})(e^{-\lambda_L t})[0.0091(e^{0.021t} - e^{-0.271t})] \qquad (3)$$

where,

C(t) = iodine-131 concentration in milk at time t (pCi/liter),

t = time after start of radioiodine intake (days),

I_o = cow's intake of radioiodine on first day (pCi), and

λ_L = pasture weathering constant due to physical and chemical actions of the environment = $0.693/t_{L\frac{1}{2}}$

$t_{L\frac{1}{2}}$ = weathering pasture half-time (days).

Equation (3) reduces to the following:

$$C(t) = (0.0091)(I_o)[e^{-(0.065+\lambda_L)t} - e^{-(0.357+\lambda_L)t}] \qquad (4)$$

It should be pointed out that, although not stated in his paper, Lengemann assumed that the physical half-life of iodine–131 due to radioactive decay while in the cow is the same as the effective (physical and weathering) half-time of iodine–131 on pasture. Since this is not the actual case, the equation would tend to underestimate the actual concentration in milk. In the method described herein, involving pasture half-time templates, the estimated pasture half-times would tend to be higher than the actual pasture half-times.

Using equation (4), a series of transparent templates were developed for weathering pasture half-times (not including radioactive decay) of 2.94, 4.17, 5.21, 6.41, 7.79, 9.36, and 57.7 days. These iodine–131 weathering pasture half-times correspond to iodine–131 milk half-times of 2.3, 3.0, 3.5, 4.0, 4.5, 5.0, and 9.0 days, respectively, for the region of Lengemann's equation (3) where the curve describes an exponential decrease. Various observed State or PMN station results were then plotted on semilog paper and fitted by hand to the developed templates. The curve providing the best fit was selected and used to define the pasture half-time, the apparent date of deposition (start of intake), and the peak iodine–131 milk concentration. This method was used only for those sampling locations which met the following criteria:

1. At least one sample from the sampling site had a milk concentration of iodine–131 of 50 pCi/liter or greater.
2. Samples were collected at least once a week at the sampling site.
3. The second milk sample from a sampling site was collected within 3 days of the collection date of the first milk sample with detectable iodine–131; or, the first milk sample had a lower io-

dine–131 concentration than the second sample.

4. Collection from a sampling site was continued until iodine–131 concentrations in milk were below detectable levels.

Data from five States (Arkansas, Indiana, Oklahoma, Texas, Utah) and 18 PMN stations met the criteria. Although the samples reported on by the Utah State Health Department met the criteria, they were determined for samples collected from tank-trucks. When the data were plotted they could not be fitted to any of the developed templates. This was assumed to have resulted from large variations in iodine–131 concentrations in milk from the various farms on a tank-truck route.

It should be pointed out that the deposition date, defined by this method does not allow for the time delay between milking and collection. The collection date is used as though it were the milking date. Hence, the actual date of deposition most likely occurred earlier than the date derived by this method. Also, if the dairy herds in a given milkshed were not on pasture at the time of actual deposition but were put on pasture at a later date, the deposition date determined by the described method would lag behind the actual deposition date.

In those cases where the daily levels of iodine–131 in milk increased relative to the theoretical curves representing a single deposition event (*i.e.*, the cow's daily iodine–131 intake increased) a graphical subtraction was performed and the values replotted to give a second curve and apparent iodine–131 deposition date. This is an apparent deposition since other factors than an actual deposition could cause the same effect on iodine–131 concentrations in milk. Cows not initially on pasture could have been placed on pasture later, or cows on pasture could have been transferred to a new pasture where contamination was greater.

Comparison between iodine–131 deposition dates derived by this method and gross beta radioactivity deposition observed by the RSN (table 7) shows in a few cases a time lag of 1 to 3 days behind the RSN data, which would be expected. However, in most cases correlation was not good.

Data from these State and PMN locations (excluding those in Utah) were fitted with templates. For the locations studied, all but two yielded pasture half-times from four to nine days as shown in table 7. The two exceptions fitted the template whose weathering pasture half-time was 58 days. In order to adequately define the curve for the shorter weathering pasture half-times, optimum sample collection should be every 3 days. For the longer weathering pasture half-time, optimum sampling would be every 5 days. This insures that at least one sample is collected while the iodine–131 concentration is increasing. The above weathering pasture half-times (4 to 9 days) yield iodine–131 half-times in milk of 3 to 5 days at the point in time where the second term in the equation becomes insignificant and the equation defines an exponential decrease.

Accumulated iodine–131 intake

On the basis of the fitted curves, it is possible to estimate the total iodine–131 intake received by a member of the general population as a result of the third Chinese atmospheric nuclear test. Assuming a daily purchase and consumption of 1 liter of milk, the accumulated iodine–131 intake can be calculated by integrating equation (4). The iodine–131 concentration of the first day was obtained from the fitted curves.

Integrating equation (4) yields the total iodine–131 intake:

$$E = (0.0091)\ (I_o)\ [(0.065+\lambda_L)^{-1} - (0.357+\lambda_L)^{-1}] \qquad (5)$$

where,

E = cumulative iodine-131 intake (pCi).

The calculated cumulative iodine–131 intake from drinking milk was 9,300 pCi in Sebastian County, Ark. This represents 1.7 percent of the Protective Action Guide for a suitable sample of a population group. The Protective Action Guide is defined by the Federal Radiation Council as the projected absorbed dose to individuals in the general population which warrants protective action following a contaminating event (*16*). The Protective Action Guide for a suitable sample of a population group is

Table 7. Iodine-131 weathering pasture half-times, deposition dates, and cumulative intakes from milk following the third Chinese nuclear test of May 9, 1966

Sampling location		Sampling code [a]	Template weathering pasture half-time (days)	Half-time in milk [b] (days)	Deposition date as determined from template fit	Observed deposition dates by RSN [c]	Milk concentration first day after intake [d] (pCi/liter)	Cumulative iodine-131 intake [e] (pCi)
Ala.:	Montgomery	P	9	5.0	May 19, 20	May 19–23, 27–28, June 10	27, 13	[illegible]
Ark.:	Little Rock	P	4	2.0	May 17, 21	(f)	440, 40	[illegible]
	Green County	S	4	2.0	May 18, 20		120, 390	[illegible]
	Lonoke County	S	4	2.0	May 18, 21		370, 42	[illegible]
	Miller County	S	4	2.0	May 19, 26		33, 66	[illegible]
	Ouachita County	S	4	2.0	May 17, 22, 30		63, 46, 60	[illegible]
	Sebastian County	S	4	2.0	May 18, 20		580, 220	[illegible]
	Washington County	S	4	2.0	May 17, June 2		500, 40	[illegible]
Ga.:	Atlanta	P	9	5.0	May 18, 26		94, 20	[illegible]
Ind.:	Indianapolis	P	9	5.5	May 19, 23	May 18, 21, June 7	93, 66	2,[illegible]
	Fort Wayne	S	9	5.0	May 19		61	1,400
	Indianapolis	S	9	5.0	May 19	May 18, 21, June 7	94	2,100
	Rochester	S	9	4.5	May 19		100	2,100
Iowa:	Des Moines	P	9	5.0	May 22, June 1, 6		30, 9, 10	1,100
Kans.:	Wichita	P	9	5.0	May 19, 21		62, 20	1,900
Minn.:	Minneapolis	P	6	3.0	May 23, 29 June 7	May 15–17, 23, 26, June 2–3, 6	33, 31, 13	810
Miss.:	Jackson	P	28	9.0	May 23	May 18–20, 23, 24	21	[illegible]
Mo.:	Kansas City	P	9	5.0	May 19, June 7		93, 17	2,[illegible]
	St. Louis	P	9	5.0	May 19, 21		150, 19	[illegible]
Nebr.:	Omaha	P	9	5.0	May 25, June 8	[g] May 17, 20, 25, 30, June 2, 5, 7	51, 22	1,000
N.C.	Charlotte	P	28	9.0	May 18	[h] May 15, 22, 24	30	1,300
Ohio:	Cincinnati	P	8	4.5	May 20		39	730
Okla.:	Oklahoma City	P	9	5.0	May 20, 27	May 21	77, 34	2,[illegible]
	Enid	S	9	5.0	May 22		66	1,200
	Lawton	S	9	5.0	May 22		60	1,300
S.C.:	Charleston	P	9	5.0	May 20		54	1,200
Tenn.:	Memphis	P	9	5.0	May 21		65	1,400
Tex.:	Austin	P	9	5.0	May 23	May 25, 29	28	650
	Dallas	P	9	5.0	May 22		53	1,200
	Lubbock County	S	9	5.0	May 24		50	1,100

[a] P, PMN sampling location. S, State sampling location.
[b] For the time period where Langemann's equation describes an exponential decrease.
[c] Gross beta radioactivity concentration of 200 pCi/liter or more per daily collection (time period—May 1 to June 10).
[d] Determined through template fit for each apparent deposition event.
[e] Assuming a 1 liter/day consumption rate.
[f] No RSN station at sampling location.
[g] RSN station—Lincoln, Nebr.
[h] RSN station—Gastonia, N.C.

one-third the Protective Action Guide for the individual.

Summary and discussion

On the basis of available information it is assumed that the intrusion of fresh fission products into the environment was the result of a single contamination event, the third Chinese atmospheric nuclear test. This data includes air, precipitation, bovine thyroid, and milk results obtained from May 9 through June 30, 1966, by both State and Public Health Service environmental surveillance programs.

During this period of time, increased levels of radioactive contamination were noted throughout the United States with peak activities occurring in the southern Midwest and southwestern Southeast. Radioactivity observed in mid-May increased steadily until late May when peak concentrations occurred in air, precipitation, bovine thyroids, and milk. Subsequently, environmental contamination decreased reaching essentially pre-intrusion values by the end of June.

A comparison between the various environmental media sampled can be made by considering results obtained in Region VII (Arkansas, Louisiana, New Mexico, Oklahoma, and Texas). The appearance of fresh fission products in air was observed between May 15 and 18 as shown in figure 8. Later, the percentage of samples containing fresh fission products increased reaching a maximum between May 22 and 25. Although the greatest percentage of air samples was affected at that time, the peak air concentration in this region occurred on May 21. Subsequent to May 25, air radioactivity concentrations were observed to decrease except for a slight intrusion between June 5 and 7 which is presumed to reflect the second passage of the debris cloud.

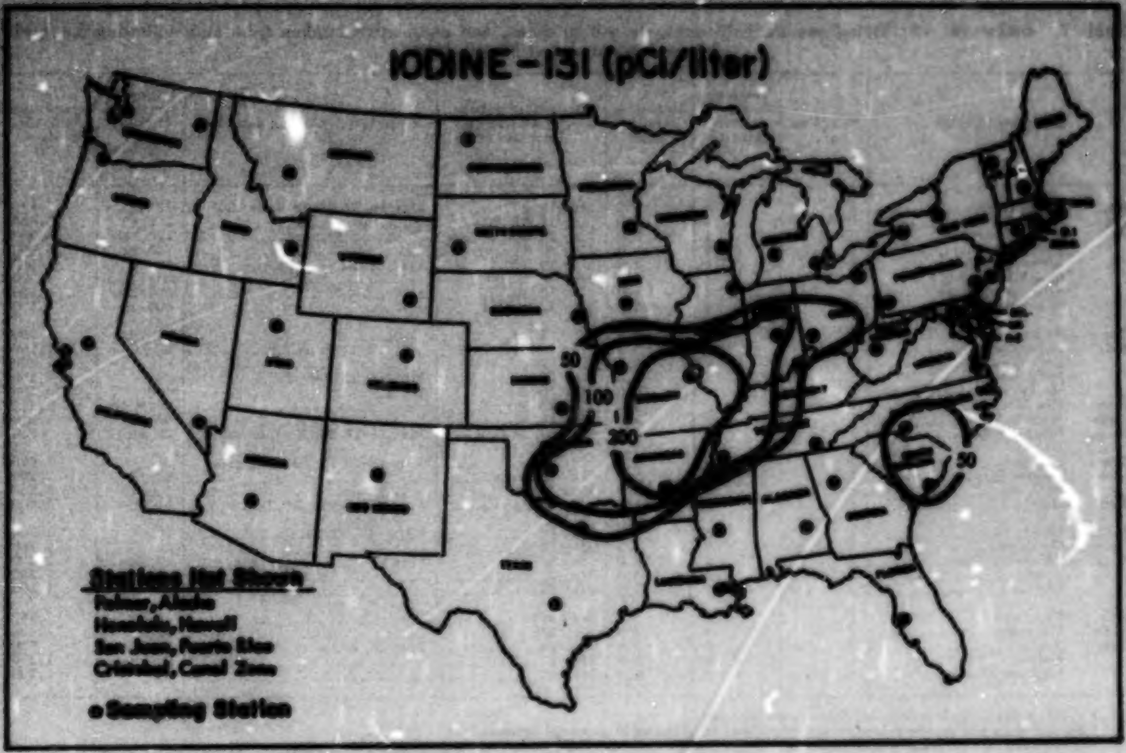


Figure 7. Iodine-131 concentrations in pasteurized milk, May 23 to 25, 1966

The percentage of precipitation samples with gross beta radioactivity concentrations greater than the minimum detectable level (200 pCi/liter) was seen to increase similarly with the percentage of air samples showing fresh fission products (figure 8). However, the precipitation sample percentages remained elevated for a greater length of time, not decreasing until mid-June.

Although the number of thyroid samples collected on any given day was small, the grouped results in terms of percentage of samples with activities greater than 10 pCi/g show a general trend of the influx of iodine-131 into the environment. It is difficult to relate thyroid iodine-131 levels to the levels observed in other environmental media; however, the influx of iodine-131 was readily observed by the Bovine Thyroid Network.

Initially, the percentage of milk samples with iodine-131 concentrations greater than 20 pCi/liter is seen to parallel the percentage of bovine thyroid results greater than 10 pCi/g; however, the milk percentages were observed to exhibit a decline sooner than the thyroid percentages. Peak iodine-131 concentrations in milk were observed to lag behind peak air gross beta radioactivities by approximately 7 days.

Equations developed by Lengemann were used to determine pasture iodine-131 weathering half-times of 4 to 9 days (two were 58 days) (*15*). Estimated iodine-131 deposition dates in a few cases lagged behind RSN observed gross beta radioactivity depositions by 1 to 3 days and reflected the time delays in the cow, time between milking, and sample collection. However, in most cases correlation was not good.

-131-

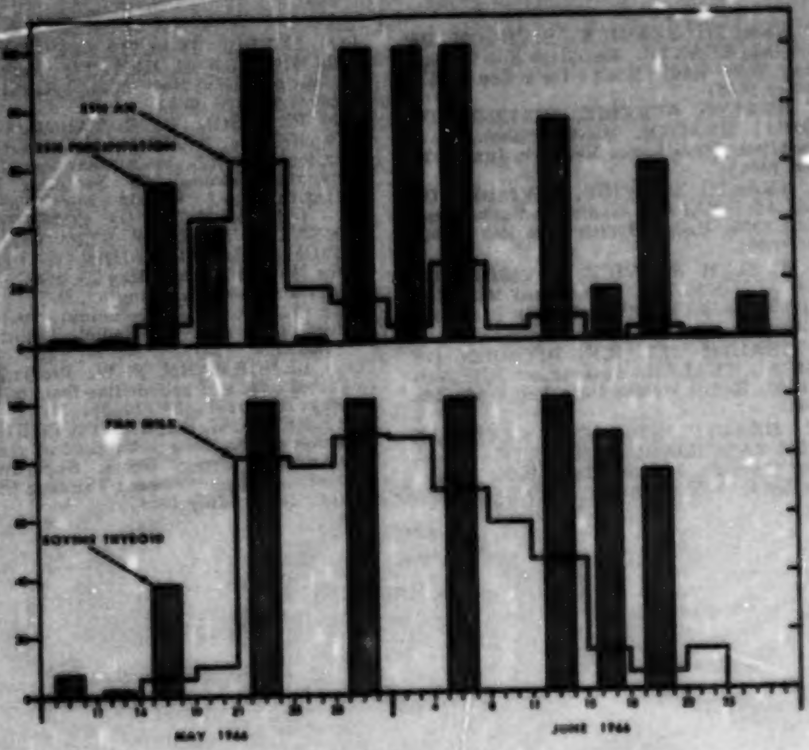


Figure 5. Percentage of air precipitation, bovine thyroids, and milk samples containing fresh fission products, region VII

Maximum iodine–131 concentrations in milk were observed in the central section of the Midwest and southwestern section of the Southeast with the peak iodine–131 concentration (920 pCi/liter) found for a sample collected in Arkansas on May 21, 1966. Cumulative intake of iodine–131 from drinking 1 liter of milk from Sebastian County, Arkansas (the county where the highest iodine–131 milk concentrations were reported) was calculated to correspond to 1.7 percent of the Protective Action Guide as defined by the Federal Radiation Council (*16*).

Acknowledgment

The authors wish to express their appreciation for the assistance received from the State personnel represented by the programs mentioned herein, without whose assistance this report would not have been possible.

REFERENCES

(*1*) PUBLIC HEALTH SERVICE, DIVISION OF RADIOLOGICAL HEALTH. Reported nuclear detonations, May 1966. Radiol Health Data Rep 7:376 (June 1966).

(*2*) PUBLIC HEALTH SERVICE, DIVISION OF RADIOLOGICAL HEALTH. Reported nuclear detonations, October 1964. Radiol Health Data 5:577 (November 1964).

(*3*) PUBLIC HEALTH SERVICE, DIVISION OF RADIOLOGICAL HEALTH. Reported nuclear detonations, May 1965. Radiol Health Data 6:332 (June 1965).

(*4*) PUBLIC HEALTH SERVICE, DIVISION OF RADIOLOGICAL HEALTH. Monthly tabulations of findings. Radiation Surveillance Network, May 1–13, 1966 (July 8, 1966).

-132-

(5) PUBLIC HEALTH SERVICE, DIVISION OF RADIOLOGICAL HEALTH. Radiation Surveillance Network, May 1966. Radiol Health Data Rep 7:511–[illegible] (September 1966).

(6) PUBLIC HEALTH SERVICE, DIVISION OF RADIOLOGICAL HEALTH. Monthly tabulation of findings. Radiation Surveillance Network, June 1–30, 1966 (August 1966).

(7) PUBLIC HEALTH SERVICE, DIVISION OF RADIOLOGICAL HEALTH. Radiation Surveillance Network, June 1966. Radiol Health Data Rep 7:[illegible] (October 1966).

(8) PUBLIC HEALTH SERVICE, DIVISION OF RADIOLOGICAL HEALTH. Pasteurized Milk Network, May 1966. Radiol Health Data Rep 7:494–497 (September 1966).

(9) PUBLIC HEALTH SERVICE, DIVISION OF RADIOLOGICAL HEALTH. Pasteurized Milk Network, June 1966. Radiol Health Data Rep 7:[illegible] (October 1966).

(10) PUBLIC HEALTH SERVICE, NATIONAL CENTER FOR RADIOLOGICAL HEALTH. Iodine-131 in bovine thyroids, January–June 1966. Radiol Health Data Rep 8:51–55 (January 1967).

(11) PUBLIC HEALTH SERVICE, DIVISION OF RADIOLOGICAL HEALTH. Radiation Surveillance Network, April 1966. Radiol Health Data Rep 7:[illegible] (August 1966).

(12) BRANSON, L., R. TABOR, G. HOLSWORTH, S. GOLD, J. HARDIN, and B. KAHN. Detection of fallout from Chinese nuclear test of October 16, 1964, by the National Air Sampling Network. Radiol Health Data 6:[illegible] (April 1965).

(13) DEPARTMENT OF COMMERCE, ENVIRONMENTAL SCIENCE SERVICES ADMINISTRATION, WEATHER BUREAU. Daily weather maps for May 15 through May 26, 1966. National Meteorological Center, Washington, D.C.

(14) OLSEN, C. D. Preliminary survey of dairy cattle feeding practices. Radiol Health Data 5:[illegible] (January 1964).

(15) LENGEMANN, F. W. Predicting the total projected intake of radioiodine from milk by man. Health Physics 12:825–830 (1966).

(16) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, Report No. 5. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (July 1964).

-133-

SECTION I. MILK AND FOOD

In the determination of the internal exposure to man from environmental radiation sources, primary interest centers on radionuclides in the diet. Efforts are being made by both Federal and State agencies to monitor the intake of various radionuclides in the total diet on a continuing basis. The total diet is the most direct measure of intake of radionuclides; however, because specific dietary data are not readily available, indicator foods may be used to estimate radionuclide intake.

Fresh milk is consumed by a large segment of the U.S. population. It contains most of the biologically significant radionuclides from nuclear test debris which appear in the diet and is the major source of dietary intake of short-lived radionuclides. For these reasons it is the single food item most often used as an indicator of the population's intake of radionuclides. In the absence of specific dietary information, one may assume that the total daily dietary intake of selected radionuclides is equivalent to the intake represented by the consumption of 1 liter of milk. More direct estimates of dietary intake of radionuclides than those furnished by indicator foods can be obtained by analysis of the total diet or representative principal food items or groups, combined with appropriate consumption data.

The Federal Radiation Council (FRC) has developed Radiation Protection Guides (RPG's) for controlling normal peacetime nuclear operations, assuming continuous exposure from intake by the population at large (*1–3*). The RPG's do not and cannot establish a line which is safe on one side and unsafe on the other; they do provide an indication of when there is a need to initiate careful evaluation of exposure (*3*). Additional guidelines are provided by the FRC Protective Action Guides (*4*) and by the International Commission on Radiological Protection (*5,6*).

Data from selected national, international, and State milk and food surveillance activities are presented herein. An effort has been made to present a cross-section of routine sampling programs which may be considered of a continuing nature. Routine milk sampling has been defined as one or more samples collected per month.

REFERENCES

(*1*) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, Report No. 1. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (May 13, 1960).

(*2*) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (September 1960).

(*3*) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, protective action for strontium–89, strontium–90, and cesium–137, Report No. 7. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (May 1965).

(*4*) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, Report No. 5. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (July 1964).

(*5*) INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION. Recommendation of the International Commission on Radiological Protection, Report No. 2. Pergamon Press, New York, N.Y. (1959).

(*6*) INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION. Recommendation of the International Commission on Radiological Protection, Report No. 6. Pergamon Press, New York, N.Y. (1965).

National and International Milk Surveillance

As part of continuing efforts to quantitatively monitor man's exposure to radionuclides, various national and international organizations routinely monitor radionuclide levels in milk. In addition to those programs presented below, *Radiological Health Data and Reports* coverage includes:

Program	Period reported	Last presented
Radiostrontium in milk, HASL	January–June 1966	March 1967

---

1. Pasteurized Milk Network
February 1967

National Center for Radiological Health and *National Center for Urban and Industrial Health, PHS*

The Public Health Service's Pasteurized Milk Network (PMN) was designed to provide nationwide surveillance of radionuclide concentrations in milk through sampling from major milk production and consumption areas. The present network of 63 stations (figure 1) provides data on milk in every State, the Canal Zone, and Puerto Rico. The most recent description of the

Table 1. Analytical errors associated with determinations of radionuclide concentrations in milk

Nuclide	Concentration (pCi/liter)	Error [a] (pCi/liter)	Concentration (pCi/liter)	Error [a] (percent of concentration)
Iodine-131	Less than 100	10	100 or greater	10
Barium-140	Less than 100	10	100 or greater	10
Cesium-137	Less than 100	10	100 or greater	10
Strontium-89	Less than 50	5	50 or greater	10
Strontium-90	Less than 20	2	20 or greater	10

[a] Two standard deviations.

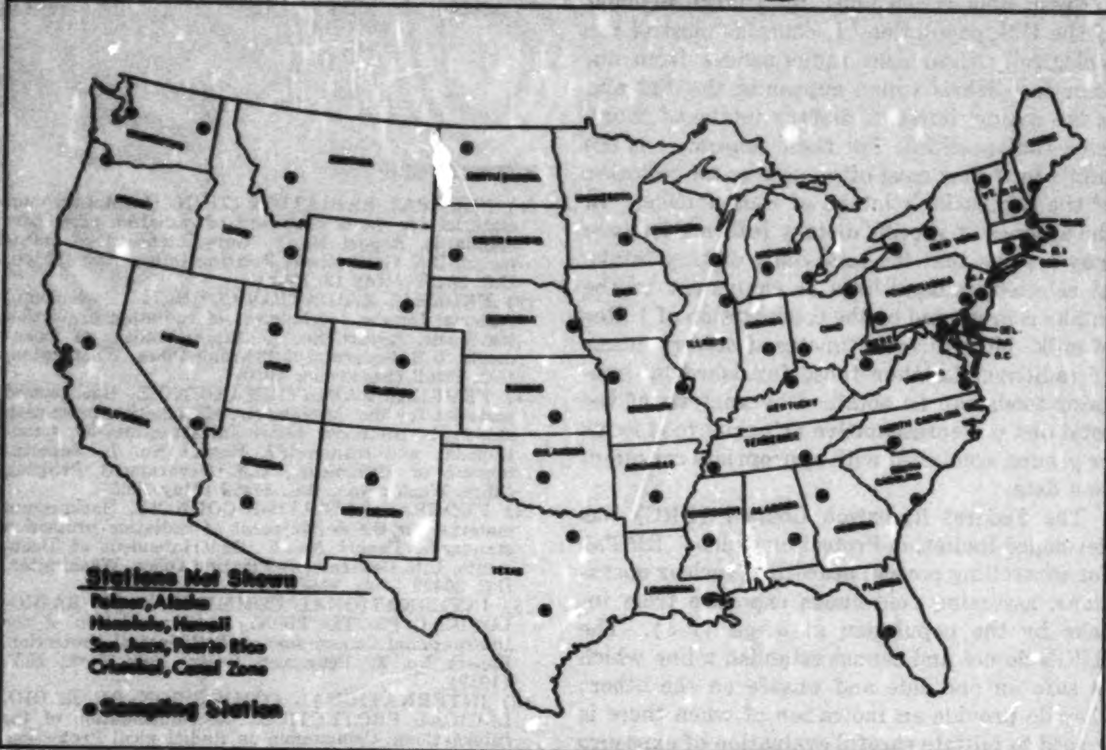


Figure 1. Pasteurized Milk Network sampling stations

Table 2. Average concentration of radionuclides in pasteurized milk for the fourth quarter 1966 and February 1967

Sampling location		Concentration (pCi/liter)									
		Strontium-89		Strontium-90		Iodine-131		Cesium-137		Barium-140	
		Fourth quarter 1966	Feb [a] 1967	Fourth quarter 1966	Feb 1967	Fourth quarter 1966	Feb 1967	Fourth quarter 1966	Feb 1967	Fourth quarter 1966	Feb 1967
Ala:	Montgomery	< 5	<5	10	11	0	0	15	15	0	0
Alaska:	Palmer	< 5	<5	14	8	0	0	25	15	0	0
Ariz:	Phoenix	< 5	<5	3	2	0	0	5	< 5	0	0
Ark:	Little Rock	< 5	<5	24	21	0	0	20	20	0	0
Calif:	Sacramento	< 5	<5	3	4	0	0	5	< 5	0	0
	San Francisco	< 5	<5	3	3	0	0	10	< 5	0	0
C. Z:	Cristobal	< 5	<5	5	5	0	0	25	20	0	0
Colo:	Denver	< 5	<5	8	6	0	0	10	< 5	0	0
Conn:	Hartford	< 5	----------	10	10	0	0	20	30	0	0
Del:	Wilmington	< 5	----------	13	11	0	0	20	20	0	0
D. C:	Washington	< 5	<5	12	9	0	0	15	10	0	0
Fla:	Tampa	10	<5	10	9	0	0	25	10	0	0
Ga:	Atlanta	< 5	<5	16	16	0	0	25	25	0	0
Hawaii:	Honolulu	< 5	<5	4	4	0	0	15	10	0	10
Idaho:	Idaho Falls	< 5	<5	9	7	0	0	15	< 5	0	0
Ill:	Chicago	< 5	<5	8	9	0	0	15	20	0	0
Ind:	Indianapolis	< 5	----------	10	11	0	0	15	20	0	0
Iowa:	Des Moines	< 5	<5	6	9	0	0	15	< 5	0	0
Kans:	Wichita	< 5	<5	14	3	0	0	10	< 5	0	0
Ky:	Louisville	10	<5	13	13	0	0	10	15	0	0
La:	New Orleans	< 5	<5	27	25	0	0	35	20	0	0
Maine:	Portland	< 5	----------	14	13	0	0	45	45	0	0
Md:	Baltimore	< 5	<5	11	11	0	0	15	50	0	0
Mass:	Boston	< 5	<5	13	13	0	0	35	35	0	0
Mich:	Detroit	< 5	----------	10	10	0	0	15	30	0	0
	Grand Rapids	< 5	----------	12	10	0	0	20	35	0	0
Minn:	Minneapolis	< 5	<5	21	15	0	0	15	10	0	0
Miss:	Jackson	15	<5	17	19	0	0	15	20	0	0
Mo:	Kansas City	< 5	<5	11	10	0	0	10	< 5	0	0
	St. Louis	< 5	<5	13	11	0	0	15	5	0	0
Mont:	Helena	< 5	<5	12	7	0	0	20	5	0	0
Nebr:	Omaha	< 5	<5	10	10	0	0	10	< 5	0	0
Nev:	Las Vegas	< 5	<5	3	2	0	0	10	< 5	0	0
N. H:	Manchester	< 5	----------	15	17	0	0	45	45	0	0
N. J:	Trenton	< 5	----------	10	10	0	0	30	25	0	0
N. Mex:	Albuquerque	< 5	<5	4	5	0	0	5	< 5	0	0
N. Y:	Buffalo	< 5	----------	9	9	0	0	20	30	0	0
	New York City	< 5	----------	13	10	0	0	25	35	0	0
	Syracuse	< 5	----------	9	10	0	0	20	30	0	0
N. C:	Charlotte	< 5	<5	20	18	0	0	30	30	0	0
N. Dak:	Minot	< 5	<5	24	17	0	0	20	15	0	0
Ohio:	Cincinnati	< 5	----------	10	11	0	0	15	20	0	0
	Cleveland	< 5	----------	10	11	0	0	20	20	0	0
Okla:	Oklahoma City	< 5	<5	9	10	0	0	10	10	0	0
Ore:	Portland	< 5	<5	10	7	0	0	20	10	0	0
Penn:	Philadelphia	< 5	----------	11	11	0	0	20	20	0	0
	Pittsburgh	< 5	----------	14	15	0	0	30	25	0	0
P. R:	San Juan	5	<5	6	6	0	0	15	15	0	0
R. I:	Providence	< 5	----------	12	11	0	0	25	30	0	0
S. C:	Charleston	< 5	<5	20	18	0	0	30	30	0	0
S. Dak:	Rapid City	< 5	<5	16	12	0	0	15	10	0	0
Tenn:	Chattanooga	< 5	<5	18	16	0	0	20	20	0	0
	Memphis	< 5	<5	14	13	0	0	10	10	0	0
Tex:	Austin	< 5	<5	4	4	0	0	5	10	0	0
	Dallas	< 5	<5	10	9	0	0	10	15	0	0
Utah:	Salt Lake City	< 5	<5	12	8	0	0	15	5	0	0
Vt:	Burlington	< 5	----------	11	11	0	10	25	30	0	0
Va:	Norfolk	10	<5	14	12	0	0	15	15	0	0
Wash:	Seattle	< 5	<5	16	11	0	0	35	25	0	0
	Spokane	< 5	<5	14	11	0	0	25	20	0	0
W. Va:	Charleston	5	<5	15	12	0	0	10	10	0	0
Wis:	Milwaukee	< 5	----------	9	8	0	0	15	30	0	0
Wyo:	Laramie	< 5	<5	8	3	0	0	10	5	0	0
Network average		< 5	<5	11.7	10.5	0	0	20	15	0	0

[a] Dashes indicate no strontium-89 determinations were made on samples from station during month.

sampling and analytical procedures employed by the PMN appeared in the December 1966 issue of *Radiological Health Data and Reports* (*1*).

-136-

Table 1 shows the approximate analytical errors (including counting error) associated with determinations of radionuclide concentrations in milk. These errors were determined by comparing results of a large number of replicate analyses. The results for February 1967 and the fourth quarter of 1966 are presented in table 2. The average monthly radionuclide concentrations are based on results obtained from samples collected weekly. If radionuclide values were below minimum detectable concentrations (*1*), averages were calculated using one-half the minimum detectable values; however, for iodine-131 and barium-140, zero was used for averaging purposes when concentrations were below minimum detectable levels.

For comparative purposes, distributions of strontium-90 and cesium-137 are presented in tables 3 and 4 for February 1966 and September 1966 through February 1967. The average strontium-90 concentrations in pasteurized milk from selected cities are presented in figure 2.

Table 3. Frequency distribution of monthly average strontium-90 concentration in milk at PMN stations, February, September-December 1966 and January-February 1967

Strontium-90 (pCi/liter)	Number of stations						
	1966					1967	
	Feb	Sept	Oct	Nov	Dec	Jan	Feb
Under 10	9	21	18	19	22	24	21
10-19	49	37	39	40	34	36	39
20-29	[illegible]	5	6	4	6	3	3
30-39	1	0	0	0	0	0	0

Table 4. Frequency distribution of monthly average cesium-137 in milk at PMN stations, February, September-December 1966 and January-February 1967

Cesium-137 (pCi/liter)	Number of stations						
	1966					1967	
	Feb	Sept	Oct	Nov	Dec	Jan	Feb
Under 50	56	61	62	61	62	62	62
50-99	6	1	0	2	1	1	1
100-149	1	1	1	0	0	0	0

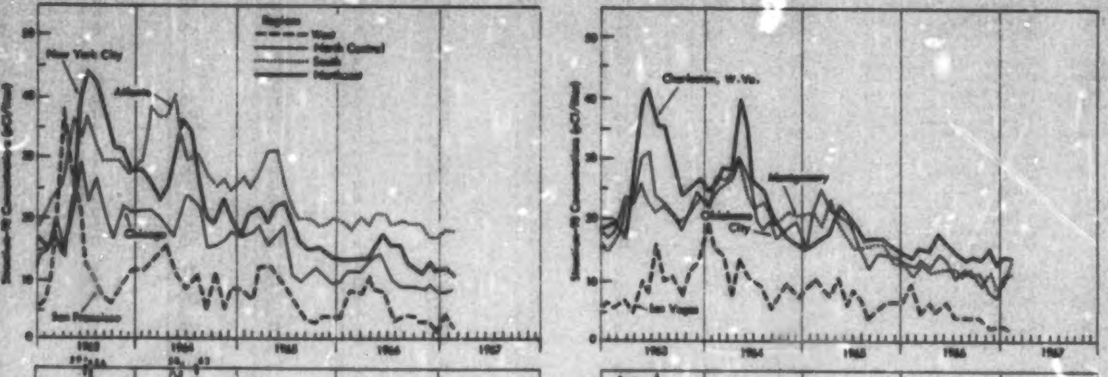


Figure 2. Strontium-90 concentrations in pasteurized milk 1961–February 1967

2. Canadian Milk Network
February 1967[1]

Radiation Protection Division
Department of National Health and Welfare

Since November 1955, the Radiation Protection Division of the Department of National Health and Welfare has been monitoring milk for radionuclide concentrations. Powdered milk was originally sampled, but liquid whole milk has been sampled since January 1963. At present, 16 milk sampling stations (figure 3) are in operation. Their locations coincide with air and precipitation sampling stations.

Milk samples are collected three times a week from selected dairies and are combined into weekly composites. The contribution of each dairy to the composite sample is directly proportional to the liquid volume of sales. Weekly spot check analyses are made for iodine-131, and monthly composites are analyzed for strontium-90, cesium-137, and stable calcium and potassium. The analytical procedures were outlined in the December 1966 issue of *Radiological Health Data and Reports* (2).

The February 1967 monthly average strontium-90, cesium-137, and stable calcium and potassium concentrations in Canadian whole milk are presented in table 5. Iodine-131 and strontium-89 were below minimum detectable levels.

Table 5. Stable elements and radionuclides in Canadian whole milk, February 1967

Station	Calcium (g/liter)	Potassium (g/liter)	Strontium-90 (pCi/liter)	Cesium-137 (pCi/liter)
Calgary	1.14	1.3	11.7	34
Edmonton	1.19	1.5	12.2	60
Ft. William	1.13	1.4	17.1	26
Fredericton	1.11	1.4	18.7	44
Halifax	1.17	1.6	10.6	47
Montreal	1.08	1.4	12.9	21
Ottawa	1.16	1.4	10.6	29
Quebec	1.10	1.5	15.2	53
Regina	1.10	1.4	10.6	29
St. John's	1.08	1.5	19.4	64
Saskatoon	1.14	1.5	13.9	27
Sault Ste. Marie	1.10	1.6	13.9	51
Toronto	1.14	1.6	8.7	23
Vancouver	1.20	1.3	17.7	76
Windsor	1.17	1.5	6.6	16
Winnipeg	1.09	1.5	9.3	32
Average	1.13	1.5	13.4	40

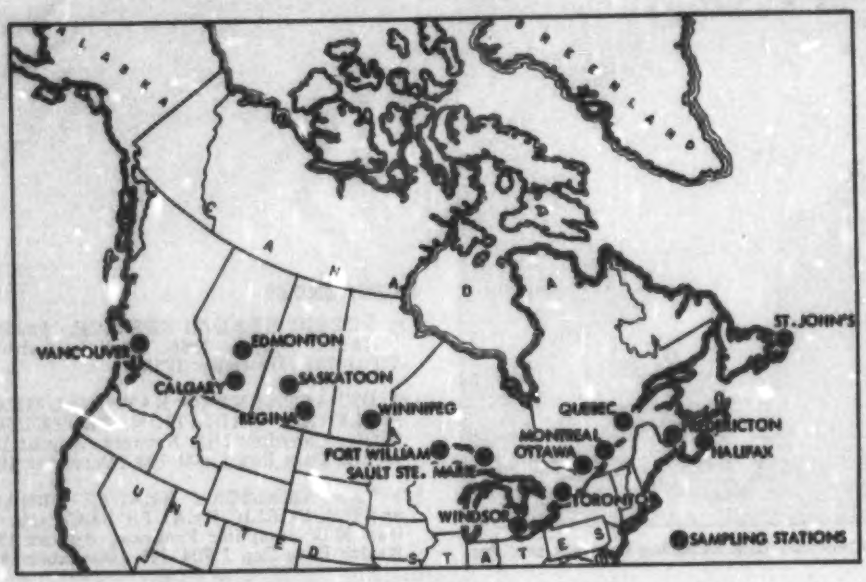


Figure 3. Canadian milk sampling stations

---

[1] Prepared from March 1967 monthly report, "Data from Radiation Protection Programs," Canadian Department of National Health and Welfare, Ottawa, Canada.

-138-

3. Pan American Milk Sampling Program February 1967

Pan American Health Organization and *U.S. Public Health Service*

The Pan American Health Organization (PAHO) in collaboration with the U.S. Public Health Service (PHS), furnishes assistance to health agencies in the American republics in developing national radiological health programs.

Under a joint agreement between agencies, air and milk sampling activities are conducted by a number of PAHO member countries (figure 4). Results of the milk sampling program are presented below. Further information on the sampling and analytical procedures employed was presented in the December 1966 issue of *Radiological Health Data and Reports* (*3*).

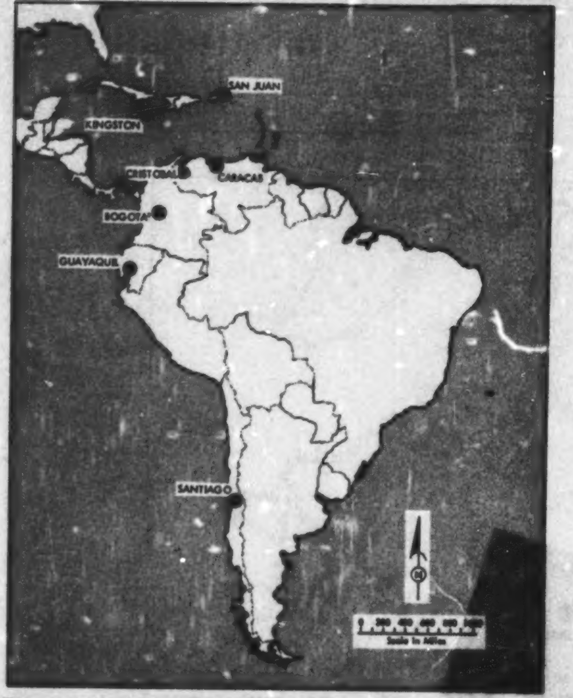


Figure 4. Pan American Milk Sampling Program stations

Table 6 presents stable potassium, strontium–90 and cesium–137 monthly average concentrations for February 1967.

Table 6. Stable element and radionuclide concentrations in PAHO milk, February 1967

Sampling stations	Number of samples	Potassium (g/liter)	Strontium-90 (pCi/liter)	Cesium-137 (pCi/liter)
Chile:				
Santiago	4	1.53	<1	< 5
Colombia:				
Bogota	1	1.39	2	5
Ecuador:				
Guayaquil	NS			
Jamaica:				
Kingston	NS			
Mandeville	NS			
Montego Bay	NS			
Venezuela:				
Caracas:				
October 1966	1	1.39	2	< 5
November 1966	1	1.39	3	5
Canal Zone:				
Cristobal [b]	4	----------	6	20
Puerto Rico:				
San Juan [b]	4	----------	6	15

[a] Strontium-89 concentrations were less than 5 pCi/liter and iodine-131 and barium-140 concentrations were less than 10 pCi/liter for all samples.

[b] For comparison purposes, the radionuclide concentrations at Cristobal, Canal Zone, and San Juan, Puerto Rico from the Pasteurized Milk Network are presented.

NS, no sample collected.

REFERENCES

(*1*) PUBLIC HEALTH SERVICE. Pasteurized Milk Network, August 1966. Radiol Health Data Rep 7:698–701 (December 1966).

(*2*) DEPARTMENT OF NATIONAL HEALTH AND WELFARE, RADIATION PROTECTION DIVISION. Canadian Milk Network, August 1966. Radiol Health Data Rep 7:702–703 (December 1966).

(*3*) PAN AMERICAN HEALTH ORGANIZATION and U.S. PUBLIC HEALTH SERVICE. Pan American Milk Sampling Program, August 1966. Radiol Health Data Rep 7:704–705 (December 1966).

State Milk Surveillance Activities

Considerable progress has been made by the State health departments in initiating or expanding environmental surveillance activities in radiological health. Many of the States have reached a point of having comprehensive environmental surveillance programs and self-sustaining radiological health laboratories.

The continuing efforts of State health departments in the analysis and monitoring of radionuclides in milk complement federal milk surveillance activities. State milk surveillance activities are continually undergoing developmental changes. The results presented herein are representative of current surveillance activities directed at the use of milk as an indicator of dietary intake of radioactivity.

In addition to the State milk networks presented herein, programs previously covered in *Radiological Health Data and Reports* include:

State milk network	Period covered	Last presented
Connecticut	October–December 1966	May 1967
Colorado	May 1965–June 1966	October 1966
Florida	April–June 1966	October 1966
Indiana	October–December 1966	May 1967
Michigan	October–December 1966	May 1967
Minnesota	October–December 1966	May 1967
New York	October–December 1966	May 1967
Oklahoma	October–December 1966	April 1967
Pennsylvania	October–December 1966	May 1967
Tennessee	July 1965–June 1966	April 1967
Texas	October–December 1966	April 1967

---

1. California Milk Network
October–December 1966

Division of Environmental Sanitation
State of California, Department of
Public Health

Surveillance of specific radionuclides in milk is one phase of the California Department of Health program on radiation control. This milk monitoring function has been conducted at eight milksheds since January 1960 by the Department's Bureau of Radiological Health. With the addition of the Del Norte and Mendocino milksheds to the program in March 1962, weekly, biweekly, or monthly sampling of pasteurized milk has been conducted at 10 major milksheds (figure 1). The original sampling locations were chosen by the State Department of Agriculture so as to be representative of milk consumed by a high percentage of the State's population. A description of the various California milksheds was presented earlier by Heslep and Cornish (*1*).

Strontium–89 and strontium–90 concentrations are determined radiochemically. Potassium–40, iodine–131, cesium–137, and barium–140 in whole fluid milk are determined by gamma-scintillation spectrometry. A detailed description of the analytical procedures was presented in an earlier report (*2*).

The monthly calcium and radionuclide concentrations in California pasteurized milk are given in table 1 for October to December 1966.

Network average strontium–90 and cesium–137 concentrations are presented graphically in figure 2.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
April–June 1966	December 1966
July–September 1966	March 1967

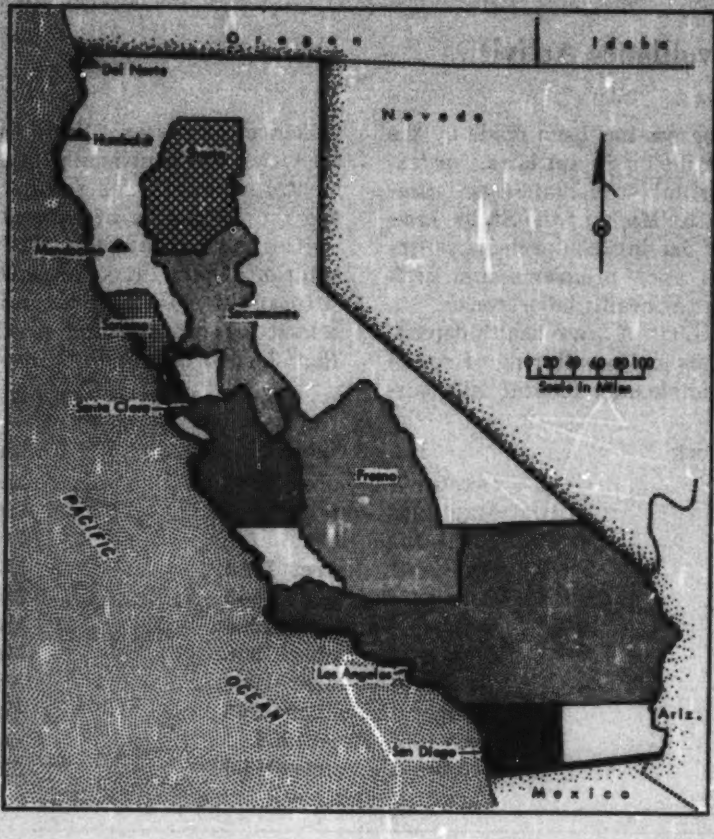

Oregon
Idaho
Nevada
Del Norte
Humboldt
Shasta
Mendocino
Sonoma
Sacramento
Santa Clara
Fresno
PACIFIC
OCEAN
Los Angeles
San Diego
Ariz.
Mexico
0 20 40 60 80 100
Scale in Miles

Figure 1. California milksheds

Table 1. Stable elements and radionuclides in California milk, October-December 1966

Sampling location	Calcium (g/liter)			Potassium-40 (pCi/liter)			Strontium-89 (pCi/liter)			Strontium-90 (pCi/liter)			Cesium-137 (pCi/liter)		
	Oct	Nov	Dec	Oct	Nov	Dec	Oct	Nov	Dec	Oct	Nov	Dec	Oct	Nov	Dec
Del Norte	1.32	1.30	NA	1,140	1,040	NA	[a] 4	72	NA	10	27	NA	21	27	NA
Fresno	1.19	1.16	1.22	1,170	1,230	1,120	ND	3	1	3	3	2	13	[a] 31	11
Humboldt	1.30	1.17	1.27	1,180	1,090	1,120	ND	8	10	6	5	8	11	[a] 6	16
Los Angeles	1.11	1.14	1.13	1,280	1,240	1,210	ND	ND	[a] 1	3	2	2	9	[a] 4	[a] 9
Mendocino	1.17	1.27	1.20	1,290	1,270	1,160	ND	[a] 3	[a] 1	5	3	3	4	14	7
Sacramento	1.18	1.23	1.25	1,210	1,190	1,220	ND	[a] 1	[a] 2	3	3	2	22	[a] 4	[a] 8
San Diego	1.15	1.14	1.13	1,350	1,250	1,240	ND	[a] 1	[a] 1	3	2	1	[a] 5	ND	[a] 5
Santa Clara	1.11	1.16	1.17	1,200	1,290	1,140	ND	[a] 1	ND	2	2	2	[a] 5	[a] 2	[a] 8
Shasta	1.15	1.15	1.13	1,220	1,240	1,160	ND	ND	ND	5	5	4	[a] 6	9	11
Sonoma	1.21	1.23	1.20	1,320	1,280	1,260	ND	ND	[a] 1	3	4	3	ND	[a] 6	[a] 4
Average	1.19	1.20	1.19	1,236	1,212	1,181	[b] ND	[b] 9	[b] 2	5	6	3	[b] 10	[b] 10	[b] 9

[a] When the counting rate of the sample is not equal to at least twice the 0.95 error, the value reported is the best available estimate, but is not statistically significant.

[b] Average is an estimate because 10 percent or more of the values averaged were not statistically significant.

NA, no analysis performed.

ND, non-detectable.

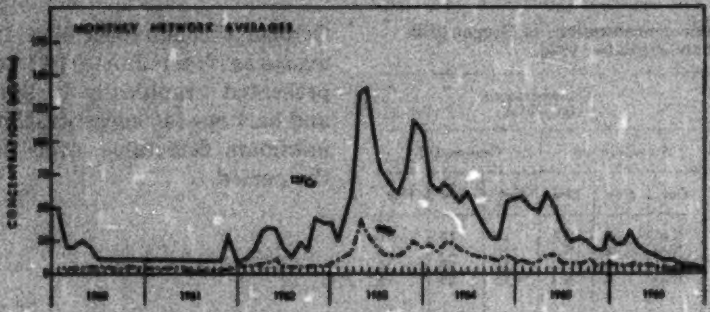


Figure 2. Radionuclide concentrations in California milk 1960–December 1966

2. Oregon Milk Network October–December 1966

Division of Sanitation and Engineering
Oregon State Board of Health

The Oregon State Board of Health has monitored radionuclide concentrations in pasteurized milk since March 1962 as part of its environmental radiation surveillance program. Currently, the Oregon milk network is comprised of seven climatically different production areas representing 90 percent of the milk distributed in Oregon (figure 3). The samples are obtained weekly in the Portland area by the City of Portland and monthly in the remaining statewide areas by the Oregon Department of Agriculture. When significant increases in radionuclide concentrations are observed, accelerated sampling is undertaken to evaluate the resulting trends.

Strontium–90 concentrations are determined using a trichloracetic acid analytical procedure (*3*). Iodine–131, cesium–137, and barium–140 concentrations are determined by gamma-scintillation spectrometry (*4*).

Table 2 gives the strontium–90 and cesium–137 concentrations in pasteurized milk from the seven milk producing areas for the period

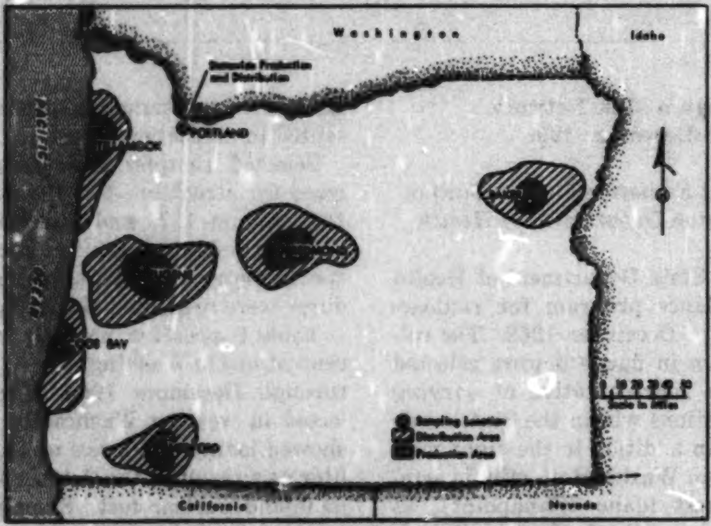

Washington
Idaho
Statewide Production and Distribution
PORTLAND
TILLAMOOK
PACIFIC
OCEAN
COOS BAY
0 10 20 30 40 50
Scale in Miles
Sampling Location
Distribution Area
Production Area
California
Nevada

Figure 3. Oregon milk production and distribution areas

Table 2. Radionuclide concentrations in Oregon milk October–December 1966

Location	Sampling frequency[a]	Concentration (pCi/liter)					
		Strontium-90			Cesium-137		
		Oct	Nov	Dec	Oct	Nov	Dec
Baker	M	NA	7	NA	40	15	15
Coos Bay	M	NA	6	NA	40	25	20
Eugene	M	NA	9	NA	35	20	15
Medford	M	NA	5	NA	<15	35	35
Nyssa[b]							
Portland composite	W	NA	11	NA	35	27	35
Portland local	W	NA	9	NA	25	20	25
Redmond	M	NA	7	NA	30	<15	35
Tillamook	M	NA	13	NA	40	35	35
Average	------	------	8	------	33	20	33

[a] M, sampled monthly
W, sampled weekly
[b] Location discontinued in September 1966.
NA, no analysis.

October through December 1966. The network averages from June 1962 to the present are presented graphically in figure 4. Iodine-131 and barium-140 concentrations remained below minimum detectable levels of 15 pCi/liter for the period.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
April–June 1966	December 1966
July–September 1966	March 1967

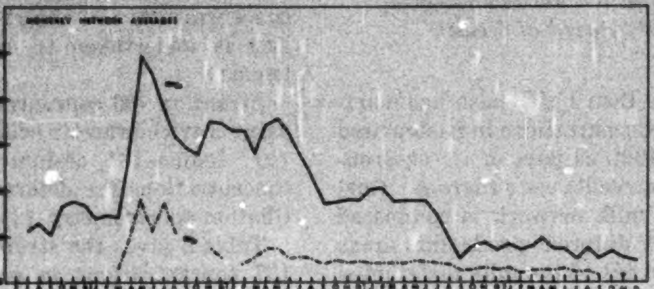


Figure 4. Radionuclide concentrations in Oregon milk network June 1962–December 1966

---

3. Washington Milk Network October–December 1966

Air Sanitation and Radiation Control Section State of Washington Department of Health

The Washington State Department of Health initiated a surveillance program for radioactivity in raw milk in December 1962. The collection points shown in figure 5 were selected to provide samples representative of varying climatological conditions within the State's two major milksheds. In addition to the eight milk sampling locations in Washington, milk is sampled from Northwest Idaho (Sandpoint), as this area forms a part of the Spokane milkshed. Details of the sampling procedures were presented in an earlier report (*5*).

Selected samples are radiochemically analyzed for strontium-90. Potassium-40, iodine-131, cesium-137, and barium-140 concentrations are determined by gamma-scintillation spectrometry. Details of the analytical procedures were presented earlier (*5*).

Table 3 presents monthly radionuclide concentrations in Washington raw milk for October through December 1966. Three samples collected in western Washington on November 9 showed iodine-131 levels of 13, 17, and 64 pCi/liter as a result of the October 27, 1966, Chinese mainland nuclear test. Samples collected both prior and subsequent to November 9 contained

- 143 -

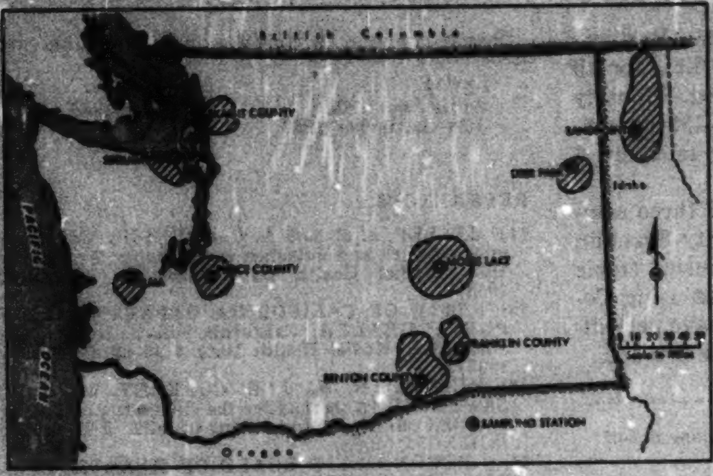

British Columbia
SKAGIT COUNTY
SEQUIM
SANDPOINT
DEER PARK
Idaho
PACIFIC OCEAN
PIERCE COUNTY
ELMA
MOSES LAKE
FRANKLIN COUNTY
BENTON COUNTY
0 10 20 30 40 50
Scale in Miles
SAMPLING STATION
Oregon

Figure 5. Washington milksheds and sampling locations

Table 3. Radionuclide concentrations in Washington milk, October-December 1966

Sampling location	Potassium-40 (pCi/liter)			Strontium-90 (pCi/liter)			Cesium-137 (pCi/liter)		
	Oct	Nov	Dec	Oct	Nov	Dec	Oct	Nov	Dec
Benton County	1,190	NS	1,210	5	NS	5	16	NS	ND
Deer Park	1,280	a 1,325	1,140	8	a 7	10	22	a 22	26
Elma	1,240	a 1,305	1,140	14	11	7	47	a 38	21
Franklin County	NS	1,190	NS	NS	4	NS	NS	ND	NS
Moses Lake	a 1,285	1,300	1,190	a 6	5	5	a 15	ND	ND
Pierce County	1,340	a 1,310	1,150	8	8	9	32	a 32	19
Sandpoint	a 1,220	1,280	1,230	a 23	26	24	a 51	47	53
Sequim	1,280	1,150	1,190	6	7	7	19	21	18
Skagit County	1,190	a 1,350	1,180	12	11	10	22	a 26	21
Average	1,253	1,268	1,179	10	10	10	28	27	24

a Represents an average of two samples collected at these sampling locations during the month.
NS, no sample collected.
ND, non-detectable (less than 15 pCi/liter).

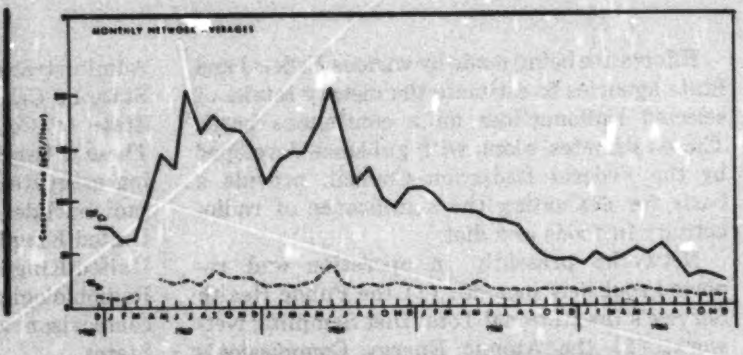


Figure 6. Radionuclide concentrations in Washington milk December 1962–December 1966

-144-

less than 10 pCi/liter of iodine-131. Barium-140 results remained below 15 pCi/liter for all samples collected during this period. Monthly average strontium-90 and cesium-137 concentrations are presented graphically in figure 6 to display general trends.

Zinc-65 was identified in one of three samples collected in the Benton County-Franklin County area during this reporting period (table 4). Milk samples produced in areas using Columbia River water for irrigation have periodically been found to contain this radionuclide.

Table 4. Washington milk samples containing zinc-65 October-December 1966

Sampling location	Collection date 1966	Zinc-65 (pCi/liter)
Benton County	October 10	< [illegible]
Franklin County	November 10	[illegible]
Benton County	December 8	< [illegible]

Recent coverage in *Radiological Health Data and Reports*:

Period	Issue
April-June 1966	December 1966
July-September 1966	March 1967

REFERENCES

(*1*) HESLEP, J. M. and A. C. CORNISH. California milk network and milkshed comparisons, April-June 1963. Radiol Health Data 4:596-599 (December 1963).

(*2*) STATE OF CALIFORNIA DEPARTMENT OF PUBLIC HEALTH. California milk network, 1962-June 1962. Radiol Health Data 4:90-93 (February 1963).

(*3*) MURTHY, G. K., J. E. COAKLEY, and J. E. CAMPBELL. A method for the elimination of ashing in strontium-90 determinations in milk. J Dairy Sci 43:151-154 (1960).

(*4*) OREGON STATE BOARD OF HEALTH, DIVISION OF SANITATION AND ENGINEERING. Oregon milk network, April-June 1965. Radiol Health Data 6:683-684 (December 1965).

(*5*) STATE OF WASHINGTON DEPARTMENT OF HEALTH, AIR SANITATION AND RADIATION CONTROL SECTION. Washington milk network, January-June 1965. Radiol Health Data 6:619-621 (November 1965).

Food and Diet Surveillance Activities

Efforts are being made by various Federal and State agencies to estimate the dietary intake of selected radionuclides on a continuous basis. These estimates, along with guidance developed by the Federal Radiation Council, provide a basis for evaluating the significance of radioactivity in foods and diet.

Networks presently in operation and reported routinely include: (1) the Public Health Service's Institutional Total Diet Sampling Network, (2) the Atomic Energy Commission's Tri-City Diet Study, (3) the Food and Drug Administration's Teenage Diet Study, (4) the State of California's Diet Study, and (5) the State of Connecticut's Standard Diet Study. These networks provide data useful for developing estimates of nationwide dietary intakes of radionuclides. Periodically, results from the United Kingdom Diet Survey, conducted by the United Kingdom Agricultural Research Council Radiobiological Laboratory, are presented for comparison with data observed in the United States.

1. Strontium–90 in Tri-City Diets May–July 1966 [1]

Health and Safety Laboratory
U.S. Atomic Energy Commission

Since March 1960, the Health and Safety Laboratory, through its quarterly diet study, has made estimates of the strontium–90 content of the average diet of individuals living in New York City, San Francisco, and Chicago.

Selected foods representing 19 food categories are purchased at each of these 3 cities every 3 months on a staggered basis (*i.e.*, New York City, May 1966; San Francisco, June 1966; and Chicago, July 1966) and are analyzed for strontium–90. Fourteen of the diet categories are analyzed on a quarterly basis. Eggs, poultry, fresh fish, shellfish, and meat are purchased quarterly, but analyzed annually. This policy was initiated in 1965 due to the lower concentrations of strontium–90 in these food categories. The contribution of these five diet categories to the total annual intake of strontium–90 over the last 4 years has been approximately 5 percent. Therefore, this figure is used to calculate their contribution to the total strontium–90 dietary intake. These values are added to contributions of the other 14 food categories to obtain quarterly estimates of annual strontium–90 intake at the 3 cities. Consumption figures used are based upon data from the Department of Agriculture (*1*).

Some food types are assumed to be representative of larger food categories, such as liquid milk for dairy products in general.

The consumption data are based on a weight-as-purchased basis. Before the food samples for the Tri-City Diet Study are ashed for radiochemical analysis, they are prepared to a certain degree as if for actual consumption. For example, fruits are peeled, eggs are shelled, and poultry is boned. Therefore, concentrations of radioactivity in foods as reported in the Tri-City Diet Study are based on the trimmed weight. No correction is made for the waste.

After two samplings at each city, it was found that the calcium content of most food categories did not vary among cities, nor did it vary significantly with time. Calcium analyses of dietary components were performed for the third time recently, and further confirmed this result (*2*). Calcium analyses were therefore discontinued and the average calcium content

Table 1. Average dietary consumption and strontium–90 intake in Tri-City diet, May–July 1966

Food category	Diet (kg/yr)	Calcium (g/yr)	New York City, May 1966		Chicago, July 1966		San Francisco, June 1966	
			(pCi/kg)	(pCi/yr)	(pCi/kg)	(pCi/yr)	(pCi/kg)	(pCi/yr)
Bakery products	37	37.0	16.4	607	12.9	477	7.5	278
Whole grain products	11	10.0	47.3	520	24.1	265	24.6	271
Fresh vegetables	43	15.0	12.9	555	16.3	701	5.8	249
Root vegetables	17	6.1	9.7	165	13.8	235	6.3	107
Milk	221	234.4	15.3	3,381	9.2	2,033	2.5	553
Flour	43	8.6	21.9	942	17.6	757	5.7	345
Macaroni	3	0.7	11.0	33	11.0	33	7.7	23
Rice	3	1.1	4.3	13	2.3	7	2.6	8
Dried beans	3	2.9	6.7	20	14.6	44	7.5	23
Fresh fruit	66	12.6	9.6	653	3.7	252	1.2	82
Potatoes	45	5.8	9.7	437	5.3	239	1.5	65
Canned fruit	25	1.3	2.1	55	2.3	60	1.3	34
Fruit juices	19	1.7	6.9	131	5.8	110	3.3	62
Canned vegetables	20	4.2	14.0	280	14.0	280	4.6	92
Meat, fish, poultry, shellfish, and eggs	99	43.0		[a] 410		[a] 289		[a] 110
Annual intake		383		8,202		5,782		2,206
Daily intake		1.05		22.5		15.8		6.0
pCi strontium–90/g Ca				21		15		6

[a] Estimated as 5 percent of total intake.

---

[1] Data from Fallout Program Quarterly Summary Report, HASL 181. Available from the Clearinghouse for Federal Scientific & Technical Information, CFSTI, 5285 Port Royal Road, Springfield, Va. 22151.

-146-

of foods was computed and used to estimate the average annual intake of this material. Details of the sampling system and a discussion of the results obtained have been summarized (*2*).

Results of the May to June 1966 sampling are presented in table 1. The variation with time of the daily intake of strontium-90 in the three cities is plotted in figure 1. A discussion of cesium-137 intakes as reflected in the Tri-City Diet Study has been presented previously (*4*).

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
May–July 1965	March 1966
August–October 1965	June 1966
November 1965–January 1966	September 1966
February–April 1966	December 1966

REFERENCES

(*1*) U.S. DEPARTMENT OF AGRICULTURE. Food consumption of households in the United States, household food consumption survey, Report No. 1, 1965. Superintendent of Documents, Government Printing Office, Washington, D.C. 20402 (December 1966).

(*2*) U.S. ATOMIC ENERGY COMMISSION. Fallout program quarterly summary report, HASL-144:281-297. Office of Technical Services, Department of Commerce, Washington, D.C. 20230 (April 1, 1964); summarized in Radiol Health Data 5:[illegible] (June 1964).

(*3*) RIVERA, J., and J. H. HARLEY. HASL contributions to the study of fallout in food chains, HASL-147. Office of Technical Services, Department of Commerce, Washington, D.C. 20230 (July 1964).

(*4*) U.S. ATOMIC ENERGY COMMISSION. Cesium-137 in Tri-City diets, 1965. Radiol Health Data Rep 8:154–157 (March 1967).

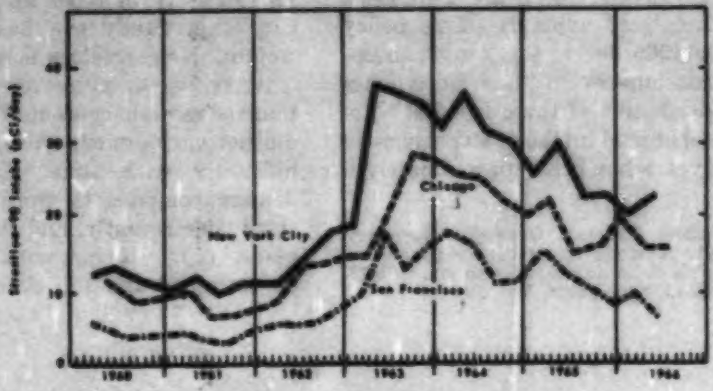


Figure 1. Daily intake of strontium-90 in Tri-City diet March 1960–July 1966

SECTION II. WATER

The Public Health Service, the Federal Water Pollution Control Administration, and other Federal, State, and local agencies operate extensive water quality sampling and analysis programs for surface, ground, and treated water. Most of these programs include determinations of gross beta and gross alpha radioactivity and specific radionuclides.

Although the determination of the total radionuclide intake from all sources is of primary importance, a measure of the public health importance of radioactivity levels in water can be obtained by comparison of the observed values with the Public Health Service Drinking Water Standards (*1*). These Standards, based on consideration of Federal Radiation Council (FRC) recommendations (*2–4*) set the limits for approval of a drinking water supply containing radium–226 and strontium–90 as 3 pCi/liter, and 10 pCi/liter, respectively. Limits may be higher if total intakes of radioactivity from all sources indicates that such intakes are within the guides recommended by FRC for control action. In the known absence[1] of strontium–90 and alpha-particle emitters, the limit is 1,000 pCi/liter gross beta radioactivity, except when more complete analysis indicates that concentrations of radionuclides are not likely to cause exposures greater than the safe limits indicated by the Radiation Protection Guides. Surveillance data from a number of Federal and State programs are published periodically to show current and long-range trends. Water programs previously reported in *Radiological Health Data and Reports* are listed below.

Program	Period reported	Last presented
Coast Guard Water Sampling	1965	November 1966
Colorado River Basin Sampling Network	1962–1964	November 1965
Drinking Water Analysis	1962	October 1965
Florida Water Sampling	1964	November 1966
Kentucky Water Sampling	May 1963–June 1964	March 1965
Lower Columbia River Radiological Survey in Oregon	August 1963–July 1964	October 1965
Minnesota Surface Water Sampling	January–June 1966	January 1967
New York Surface Water Sampling	June–December 1965	June 1966
North Carolina Water Sampling	1964	November 1965
Washington Surface Water Sampling	July 1964–June 1965	May 1966

---

[1] Absence is taken to mean negligibly small fraction of the specific limits of 3 pCi/liter and 10 pCi/liter for unidentified alpha-particle emitters and strontium–90, respectively.

REFERENCES

(*1*) U.S. PUBLIC HEALTH SERVICE. Drinking water standards, revised 1962, PHS Publication No. 956. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (March 1963).

(*2*) FEDERAL RADIATION COUNCIL. Radiation Protection Guidance for Federal Agencies. Memorandum for the President, September 1961, reprint from the Federal Register of September 26, 1961.

(*3*) FEDERAL RADIATION COUNCIL. Background material for the development of Radiation Protection Standards, Report No. 1. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (May 1960).

(*4*) FEDERAL RADIATION COUNCIL. Background material for the development of Radiation Protection Standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (September 1961).

Gross Radioactivity in Surface Waters of the United States, December 1966

Division of Pollution Surveillance
Federal Water Pollution Control Administration
Department of Interior

The monitoring of levels of radioactivity in surface waters of the United States was begun in 1957 as part of the Federal Water Pollution Control Administration's Water Pollution Surveillance System. Table 1 presents the current preliminary results of the alpha- and beta-particle analysis. The radioactivity associated with dissolved solids provides a rough indication of the levels which would occur in treated water, since nearly all suspended matter is removed by treatment processes. Strontium-90 results are reported semiannually. The stations on each river are arranged in the table according to their distance from the headwaters. Figure 1 indicates the average total beta radioactivity in suspended-plus-dissolved solids in raw water collected at each station. A description of the sampling and analytical procedures was published in the June 1966 issue of *Radiological Health Data and Reports*.

Complete data and exact sampling locations for 1958 through 1963 are published in annual compilations (*1–6*). Data for subsequent years are available on request.

Special note is taken when the alpha radioactivity is 15 pCi/liter or greater or when the beta radioactivity is 150 pCi/liter or greater. These arbitrary levels provide a basis for the selection of certain data and for comment on the data, if needed. They reflect no public health significance as the Public Health Service drinking water standards have already pro-

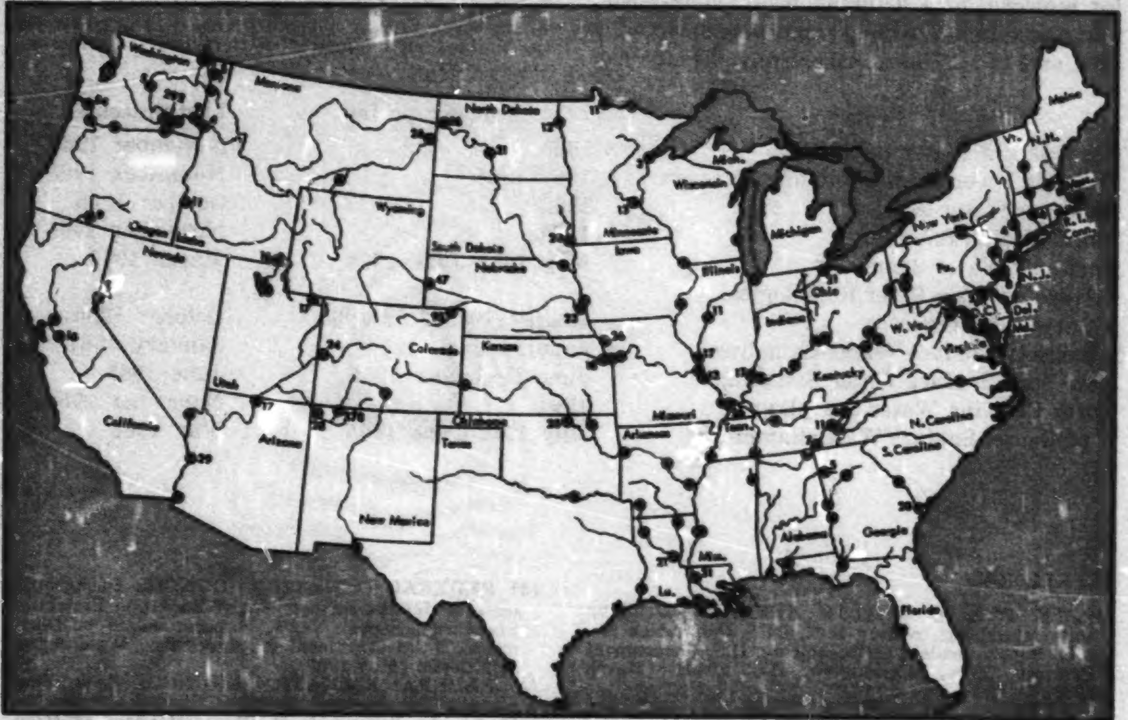

Washington
Montana
North Dakota
Oregon
Idaho
Wyoming
South Dakota
Nebraska
Nevada
California
Utah
Colorado
Kansas
Arizona
New Mexico
Oklahoma
Texas
Minnesota
Iowa
Wisconsin
Mich.
Michigan
Illinois
Indiana
Ohio
Missouri
Arkansas
Kentucky
Tenn.
Miss.
La.
Alabama
Georgia
Florida
S. Carolina
N. Carolina
Virginia
W. Va.
Md.
Del.
N.J.
Pa.
New York
Conn.
R.I.
Vt.
N.H.
Maine

Figure 1. Sampling locations and associated total gross beta radioactivity (pCi/liter) for surface waters, December 1966

-149-

vided the basis for this assessment. Changes from or toward these arbitrary levels are also noted in terms of changes in radioactivity per unit weight of solids. No discussion of gross radioactivity per gram of dissolved or suspended solids for all stations of the Water Pollution Surveillance System will be attempted at this time. Comments are made only on monthly average values. Occasional high values from single weekly samples may be absorbed into a relatively low average. When these values are significantly high, comment will be made.

During both November and December 1966, the following stations showed alpha radioactivity in excess of 15 pCi/liter on either dissolved or suspended solids:

North Platte River; Henry, Nebr.
South Platte River; Julesburg, Colo.

During December 1966, Loma, Colo., on the Colorado River showed a decline of alpha radioactivity to less than 15 pCi/liter on suspended solids.

Cedar Hill, N. Mex., on the Animas River, as a result of a single sample collected December 7, 1966, with a very high quantity of suspended solids, showed both alpha and beta radioactivities in excess of 15 pCi/liter and 150 pCi/liter, respectively, for the monthly average. Pasco, Wash., on the Columbia River showed beta radioactivity on dissolved solids in excess of 150 pCi/liter.

Table 1. Radioactivity in raw surface waters, December 1966

Station	Average beta radioactivity (pCi/liter)			Average alpha radioactivity (pCi/liter)		
	Suspended	Dissolved	Total	Suspended	Dissolved	Total
Animas River:						
Cedar Hill, N. Mex.	269	9	278	73	1	74
Arkansas River:						
Ponca City, Okla.	2	18	20	0	5	5
Atchafalaya River:						
Morgan City, La.	27	9	36	10	1	11
Bear River:						
Preston, Idaho	0	16	16	0	2	2
Big Sioux River:						
Sioux Falls, S. Dak.	1	19	20	0	3	3
Chena River:						
Fairbanks, Alaska	0	2	2	0	0	0
Clearwater River:						
Lewiston, Idaho	2	2	4	0	0	0
Clinch River:						
Clinton, Tenn.	0	4	4	0	0	0
Kingston, Tenn *	1	10	11	0	< 1	< 1
Colorado River:						
Loma, Colo.	10	14	24	3	8	11
Page, Ariz.	0	17	17	0	4	4
Parker Dam, Calif-Ariz.	2	27	29	0	10	10
Columbia River:						
Wenatchee, Wash.	1	4	5	0	0	0
Pasco, Wash *	49	243	292	0	< 1	< 1
Clatskanie, Ore.	13	42	54	0	0	0
Connecticut River:						
Enfield Dam, Conn.	1	3	4	0	0	0
Coosa River:						
Rome, Ga.	2	3	5	< 1	0	< 1
Delaware River:						
Philadelphia, Pa.	3	5	8	1	0	1
Great Lakes:						
Duluth, Minn.	0	3	3	0	0	0
Green River:						
Dutch John, Utah	0	17	17	0	3	3
Hudson River:						
Poughkeepsie, N.Y.	1	3	4	0	0	0
Illinois River:						
Peoria, Ill.	1	10	11	0	1	1
Grafton, Ill.	6	11	17	1	0	1
Kansas River:						
DeSoto, Kans.	1	17	18	0	3	3
Klamath River:						
Keno, Ore.	2	7	9	0	0	0
Maumee River:						
Toledo, Ohio	8	13	21	3	1	4
Mississippi River:						
St. Paul, Minn.	0	13	13	0	1	1
E. St. Louis, Ill.	3	9	12	0	1	1
New Roads, La.	9	22	31	2	1	3
New Orleans, La.	1	8	9	0	1	1
Missouri River:						
Williston, N. Dak.	2	14	16	1	4	5
Bismarck, N. Dak.	5	16	21	1	4	5
St. Joseph, Mo.	3	23	26	0	3	3
North Platte River:						
Henry, Nebr.	7	40	47	< 1	32	33
Ohio River:						
Cairo, Ill.	16	10	26	4	0	4
Pend Oreille River:						
Albeni Falls Dam, Idaho	1	4	5	0	< 1	< 1
Platte River:						
Plattsmouth, Nebr.	6	17	23	2	9	11
Potomac River:						
Washington, D.C.	0	4	4	0	0	0
Rainy River:						
Baudette, Minn.	< 1	11	11	0	0	0
Red River, North:						
Grand Forks, N. Dak.	1	11	12	0	1	1
Red River, South:						
Alexandria, La.	2	19	21	0	0	0
San Joaquin River:						
Vernalis, Calif.	7	9	16	1	2	3
San Juan River:						
Shiprock, N. Mex.	14	14	28	5	6	11
Savannah River:						
Port Wentworth, Ga *	4	16	20	0	0	0
Snake River:						
Payette, Idaho	1	10	11	0	4	4
Wawawai, Wash.	1	8	9	0	2	2
South Platte River:						
Julesburg, Colo.	19	76	95	3	35	38
Susquehanna River:						
Conowingo, Md.	1	4	5	0	0	0
Tennessee River:						
Chattanooga, Tenn.	< 1	7	7	0	0	0
Wabash River:						
New Harmony, Ind.	7	10	17	2	1	3
Yellowstone River:						
Sidney, Mont.	1	25	26	0	4	4
Maximum	269	243	292	73	35	74
Minimum	0	2	2	0	0	0

* Gross beta radioactivity at this station may not be directly comparable to gross beta radioactivity at other stations because of the possible contribution of radionuclides from an upstream nuclear facility in addition to the contribution from fallout and naturally occurring radionuclides common to all stations.

REFERENCES

(1) PUBLIC HEALTH SERVICE, DIVISION OF WATER SUPPLY AND POLLUTION CONTROL. National water quality network annual compilation of data, PHS Publication No. 663, 1958 Edition. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.
(2) *Ibid.*, 1959 Edition.
(3) *Ibid.*, 1960 Edition.
(4) *Ibid.*, 1961 Edition.
(5) *Ibid.*, 1962 Edition.
(6) PUBLIC HEALTH SERVICE, DIVISION OF WATER SUPPLY AND POLLUTION CONTROL. Water pollution surveillance system, annual compilation of data, PHS Publication No. 663 (Revised, 1963 Edition). Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

Radiostrontium in Tap Water, March–November 1966[1]

Health and Safety Laboratory
U.S. Atomic Energy Commission

The Health and Safety Laboratory has performed analyses for strontium-90 in tap water at New York City since August 1954. Samples of tap water are collected daily so that by the end of the month a composite of at least 100 liters is available for analysis. Cesium-137 determinations were begun in January 1964. The analytical methods used at the laboratory are given in the Health and Safety Laboratory Manual of Standard Procedures (*1*).

Strontium-90 concentration and cesium-137/strontium-90 ratios in New York City tap water for March through November 1966 are presented in table 1. These results appear graphically in figure 1.

Table 1. Radiostrontium in New York City tap water March-November 1966

Date 1966	New York City	
	Strontium-90 [a] (pCi/liter)	Cesium-137/strontium-90 ratio
March	1.64	0.13
April	.56	.14
May	1.19	.16
June	1.63	.17
July	.92	.24
August	.80	.31
September	.82	.12
October	.76	.09
November	.80	.14

[a] Approximately 100 liters per sample.

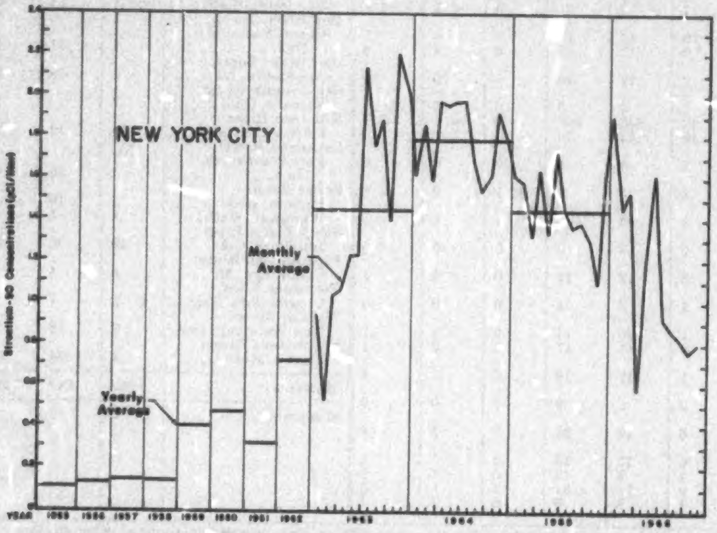


Figure 1. Strontium-90 concentrations in New York City tap water

---

[1] Prepared from information appearing in Fallout Program Quarterly Summary Report, HASL-181. This report is available from the Clearinghouse for Federal Scientific and Technical Information, CFSTI, 5285 Port Royal Road, Springfield, Va. 22151.

A decreasing trend has been observed in the strontium-90 concentrations since the July 1963 peak. The maximum strontium-90 concentrations observed are below the acceptable limit as set forth in the interstate carrier drinking water standards (*2*).

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
May and July–November 1965	June 1966
November 1965–June 1966	December 1966

REFERENCES

(*1*) U.S. ATOMIC ENERGY COMMISSION. Manual of standard procedures 40:E-38-01-16. Health and Safety Laboratory, U.S. Atomic Energy Commission, 376 Hudson Street, New York 14, N.Y.

(*2*) FEDERAL REGISTER RULES AND REGULATIONS. Title 42-Public Health, Chapter 1-Public Health Service, Department of Health, Education, and Welfare; Part 72, Interstate Quarantine, Subpart J, Drinking Water Standards 27:2154–5. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (March 6, 1962).

Radioactivity in California Waters,[1] January–June 1966

Bureau of Radiological Health, State of
California Department of Public Health

Gross beta radioactivity in California domestic waters is monitored by the State of California's Bureau of Radiological Health. The importance of this program in the State's environmental surveillance activities stems from the fact that most of California's domestic water supplies are of surface origin.

Radioactivity in such water supplies consists of the natural radioactivity in surface streams, radioactivity added by the discharge of sewage or by industrial waste effluents, and radioactivity from fallout, particularly fallout into open terminal or distribution reservoirs. Present efforts consist of sampling raw and treated surface waters and well waters. It should be noted that except for large metropolitan water supplies, raw water sampling is being phased out and treated water sampling being substituted or continued. This procedural change is predicted upon sampling water at the point of consumption.

Most of the supplies sampled have, as a source, raw surface waters (figure 1), although a few wells, along with some water supplies that use infiltration galleries, are also sampled.

Monitoring of domestic water supplies is on a continuing basis, since it has not been possible to forecast levels of radioactivity in these supplies based upon levels in rain, snow, or surface streams. Under the present sampling schedule, monthly 500-ml samples are collected and the total solids analyzed for alpha and beta radioactivity. In addition, 3-liter samples are collected monthly for approximately 6 months and composited for specific radionuclide analysis on a semiannual basis.

Analytical procedures

Radionuclide analyses of water are carried out in the State's Sanitation and Radiation Laboratory. Measurements of alpha and alpha-plus-beta radioactivities are made with a low-background windowless gas-flow proportional counter. Counting methods used follow those recommended by the U.S. Public Health Service (*1*).

Individual samples are evaporated to dryness and the residue ashed at 450° C. The ashed sample is dissolved and transferred to an aluminum planchet for beta-particle counting. Gamma-emitting radionuclides and radium-226 are determined semiannually on the composite samples by gamma-ray spectroscopy.

---

[1] Data from July and October 1966 issues of Radiological Health News, State of California, Department of Public Health, Bureau of Radiological Health, 2151 Berkeley Way, Berkeley 4, Calif.

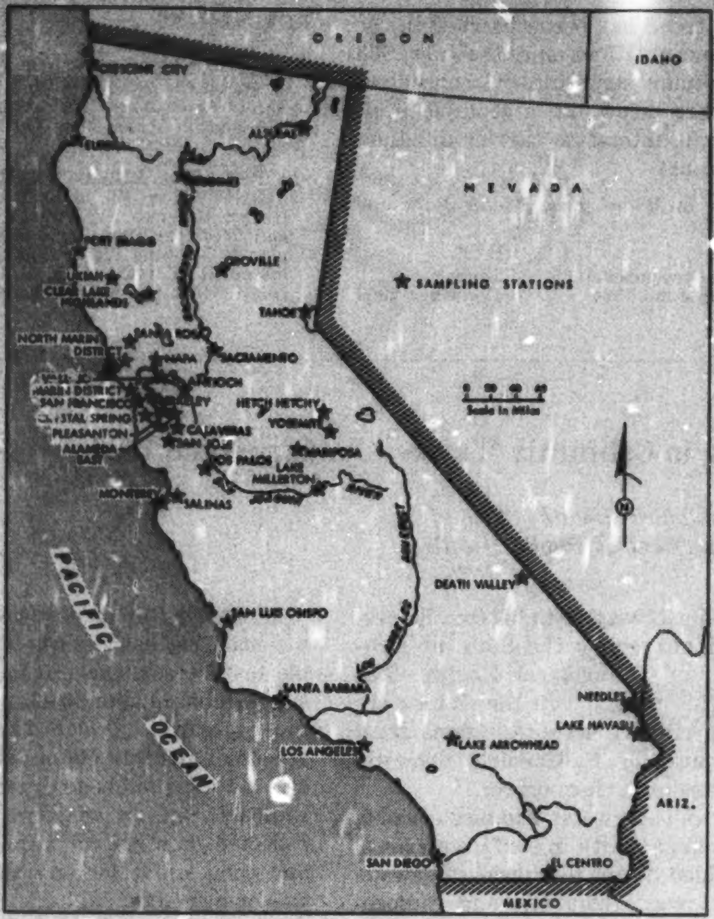

OREGON
IDAHO
NEVADA
CRESCENT CITY
ALTURAS
FORT BRAGG
OROVILLE
UKIAH
CLEAR LAKE HIGHLANDS
TAHOE
SAMPLING STATIONS
NORTH MARIN DISTRICT
SANTA ROSA
NAPA
SACRAMENTO
MARIN DISTRICT
SAN FRANCISCO
ANTIOCH
BERKELEY
HETCH HETCHY
YOSEMITE
CRYSTAL SPRING
PLEASANTON
CALAVERAS
SAN JOSE
ALAMEDA EAST
MARIPOSA
LOS BANOS
LAKE MILLERTON
Scale in Miles
MONTEREY
SALINAS
PACIFIC OCEAN
DEATH VALLEY
SAN LUIS OBISPO
SANTA BARBARA
NEEDLES
LAKE HAVASU
LOS ANGELES
LAKE ARROWHEAD
ARIZ.
SAN DIEGO
EL CENTRO
MEXICO

Figure 1. California surface water sampling stations

Discussion

Table 1 shows the monthly average beta radio activity in the suspended-plus-dissolved solids in surface water supplies in California from January through June 1966. Following treatment, these waters are used for industrial and domestic purposes. Because alpha radioactivity in water has, in general, been undetectable or very slight, these results are not presented. No increase in radioactivity level of surface water has been observed. Table 2 shows specific radionuclide concentrations in California surface waters for 1965 through 1966 by stations. Due to its health significance, the analysis of radium-226 in water was begun several years ago. Table 3 presents concentrations of radium in California water supplies for 1964 through 1965.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
January–June 1965	March 1966
July–December 1965	November 1966

REFERENCE

(*1*) PUBLIC HEALTH SERVICE, DIVISION OF RADIOLOGICAL HEALTH. Radionuclide analyses of environmental samples, R 59-6. Radiological Health Research Activities, Robert A. Taft Sanitary Engineering Center, Cincinnati, Ohio 45226 (November 16, 1959).

-153-

Table 1. Gross beta radioactivity in California domestic waters, January-June 1966

Sampling station	Quality	Concentration (pCi/liter) January	February	March	April	May	June
Alturas	Well	[a]10	ND	NS	[a]5	NS	NS
Antioch	Treated	ND	ND	[a]8	ND	ND	ND
Lake Arrowhead	Treated	NS	NS	[a]5	[a]3	[a]5	NS
Berkeley	Treated	29	[a]3	[a]24	ND	ND	ND
Clearlake Highlands	Treated	NS	[a]17	ND	[a]11	[a]3	[a]19
Crescent City	Well	ND	ND	100	[a]20	[a]8	[a]4
Death Valley	Treated	26	15	[a]9	[a]10	[a]22	65
Dos Palos	Treated	[a]12	[a]19	ND	[a]12	[a]3	ND
El Centro	Treated	ND	ND	ND	40	[a]19	[a]1
Eureka	Raw	[a]3	ND	[a]3	[a]20	ND	[a]3
	Treated	ND	ND	[a]6	ND	[a]3	ND
Fort Bragg	Treated	NS	NS	NS	NS	[a]6	ND
Los Angeles Laboratory	Raw	[a]16	[a]17	[a]17	[a]24	[a]25	[a]7
Marin Municipal Water District	Treated	137	NS	NS	[a]16	ND	ND
Mariposa	Treated	ND	[a]3	[a]5	[a]1	[a]3	[a]13
Metropolitan Water District of Southern California:							
Lake Havasu	Raw	ND	[a]19	[a]11	NS	NS	[a]12
Weymouth Plant	Treated	[a]15	ND	[a]10	[a]24	[a]5	NS
Lake Millerton	Raw	[a]5	[a]8	24	ND	[a]6	[a]12
Monterey	Treated	ND	[a]5	[a]7	[a]7	ND	NS
Napa	Treated	ND	ND	[a]4	[a]3	ND	[a]8
Needles	Well	[a]25	[a]3	[a]1	[a]15	[a]22	[a]2
North Marin Water District	Treated	[a]6	[a]10	[a]15	[a]6	[a]22	NS
	Raw	[a]9	[a]16	[a]9	[a]3	[a]6	NS
	Sludge[b]	23	ND	[a]21	ND	[a]20	NS
Oroville:							
California Water Service	Treated	[a]2	ND	[a]3	ND	ND	ND
Wyandotte Irrigation District	Treated	[a]6	NS	[a]3	[a]1	[a]9	ND
Pleasanton	Well	[a]22	[a]7	ND	[a]7	ND	ND
Redding	Treated	NS	NS	[a]10	[a]1	ND	[a]18
Sacramento	Treated	NS	ND	[a]13	[a]9	[a]2	[a]2
Salinas	Well	NS	ND	[a]12	[a]12	NS	NS
San Diego	Raw	37	[a]7	[a]10	ND	[a]20	[a]26
	Treated	[a]21	[a]7	[a]13	[a]9	[a]25	[a]9
San Francisco:							
Water Department	Raw	[a]10	[a]12	[a]9	[a]14	[a]11	[a]2
Alameda, East	Raw	NS	[a]6	[a]8	[a]3	[a]8	ND
Brightside Weir	Raw	NS	[a]14	ND	[a]6	ND	ND
Calaveras Reservoir	Raw	NS	[a]5	[a]8	ND	[a]4	ND
Crystal Springs	Raw	NS	[a]6	ND	ND	[a]12	ND
Hetch Hetchy	Raw	ND	[a]10	ND	[a]14	[a]13	ND
San Jose	Raw	ND	ND	ND	ND	[a]11	NS
San Luis Obispo	Treated	[a]1	NS	NS	NS	NS	NS
Santa Barbara	Treated	[a]8	ND	[a]7	[a]8	ND	[a]5
Santa Rosa	Raw	ND	[a]4	ND	[a]5	ND	[a]3
	Well	ND	[a]5	NS	[a]9	NS	NS
Tahoe City	Raw	[a]4	ND	NS	[a]1	ND	NS
Ukiah	Well	NS	[a]1	NS	ND	ND	ND
Vallejo:							
Fleming Hill	Raw	[a]10	[a]10	[a]4	ND	ND	ND
	Treated	ND	ND	ND	[a]7	ND	[a]15
Swanzy Reservoir	Treated	[a]8	[a]5	[a]18	[a]11	ND	[a]1
Yosemite	Treated	[a]5	[a]16	[a]6	[a]21	ND	ND
Maximum		137	19	100	40	25	65
Minimum		1	1	1	1	2	1

---

[a] When the counting rate of the sample is not equal to at least twice the 0.95 error, the value reported is the best estimate, but is not statistically significant.

[b] Sludge reported in pCi/g (dry weight).

ND, no detectable activity.

NS, no sample collected.

-154-

Table 2. Radionuclide concentrations in composite samples of California surface water, 1965–1966

Sampling station and date	Concentration (pCi/liter)					
	Potassium-40	Manganese-54	Strontium-90	Zirconium-niobium-95	Cesium-137	Cerium-141-Cerium-144
Antioch: July-December 1965	*2	ND	1	ND	ND	ND
Berkeley: July-December 1965	*1	ND	1	ND	2	ND
Dos Palos: September 1965-February 1966	*3	ND	1	ND	ND	ND
El Centro: July-December 1965	8	ND	4	ND	1	ND
Fort Bragg: January-December 1965	*1	1	1	ND	1	1
Metropolitan Water District of Southern California Weymouth Plant: July-December 1965	ND	ND	ND	ND	ND	ND
Lake Millerton: July-December 1965	*2	ND	1	ND	ND	ND
Monterey: August 1965-February 1966	*1	ND	ND	ND	ND	*1
Napa: July-December 1965	*1	ND	1	ND	ND	ND
Needles: July-December 1965	9	1	ND	ND	1	1
North Marin Water District: July-December 1965	6	ND	2	ND	ND	ND
Redding: July-December 1965	*2	ND	ND	ND	ND	ND
Sacramento: October 1965-March 1966	*3	ND	1	ND	ND	3
San Diego: July-December 1965	*4	ND	2	<0.1	ND	ND
San Francisco: January-December 1965	1	ND	1	ND	ND	ND
Santa Barbara: August 1965-February 1966	3	ND	1	ND	ND	1
Santa Rosa: July-December 1965	4	ND	1	ND	ND	ND
Tahoe City: July-December 1965	*4	ND	1	*1	1	ND
Vallejo: July-December 1965	2	ND	1	ND	ND	ND
Yosemite: July-December 1965	*3	ND	1	*1	ND	ND

* When the counting rate of the sample is not equal to at least twice the 0.95 error, the value reported is the best available estimate, but is not statistically significant.

ND—no detectable activity

Table 3. Radium-226 in California domestic water, 1964–1965

Sampling station	Sampling date	Concentration (pCi/liter)	Sampling station	Sampling date	Concentration (pCi/liter)
Antioch	4/18/65	0.066	Oroville:		
Berkeley	1/1/65	.000	California Water Service	1/16/65	0.010
	1/13/65	.006		7/1/65	.022
	4/3/65	.016	Wyandotte Irrigation District	1/16/65	.040
Crescent City	10/1/64	.002		7/1/65	.008
Dos Palos	7/1/64	.005	Redding	2/15/65	.022
	12/2/64	.045		10/1/65	.019
	7/1/65	.001	Sacramento	9/16/64	.008
El Centro	1/3/64	.050		10/1/64	.010
	7/18/64	.090		2/1/65	.008
	2/1/65	.140	San Diego	8/10/64	.200
	10/1/65	.110		2/3/65	.160
Eureka	4/1/64	.020		8/31/65	.117
	10/1/64	.012	San Jose	4/1/65	.022
Fort Bragg	7/1/65	.020	Santa Barbara	11/20/64	.040
Marin Municipal Water District	6/16/64	.000		12/15/64	.070
Metropolitan Water District of Southern California	10/1/64	.200		6/1/65	.023
Lake Millerton	5/1/64	.010	Santa Rosa	10/1/64	.008
	11/1/64	.030		3/3/65	.010
	9/16/65	.002	Scotia	11/9/64	.020
Monterey	5/1/64	.020	Tahoe City	11/30/64	.010
	11/16/64	.030		4/2/65	.010
	4/16/65	.033	Ukiah	4/1/64	.010
Napa	9/1/64	.010	Yosemite	7/1/64	.010
	3/1/65	.002		4/1/65	.012
Needles	10/1/65	.013			
North Marin Water District	10/1/64	.007			
	4/1/65	.007			
	10/1/65	.005			

SECTION III. AIR AND DEPOSITION

Radioactivity in Airborne Particulates and Precipitation

Continuous surveillance of radioactivity in air and precipitation provides one of the earliest indications of changes in environmental fission product activity. To date, this surveillance has been confined chiefly to gross beta-particle analysis. Although such data are insufficient to assess total human radiation exposure from fallout, they can be used to determine when to modify monitoring in other phases of the environment.

Surveillance data from a number of programs are published monthly and summarized periodically to show current and long-range trends of atmospheric radioactivity in the Western Hemisphere. These include data from activities of the Public Health Service, the Canadian Department of National Health and Welfare, the Mexican Commission of Nuclear Energy, and the Pan American Health Organization.

An intercomparison of the above networks was performed by Lockhart and Patterson in 1962 and is summarized in the January 1964 issue of *Radiological Health Data*. In addition to those programs presented in this issue, the following programs were previously covered in *Radiological Health Data and Reports:*

Network	Period reported	Last presented
HASL Fallout Network	July–December 1965	September 1966
HASL 80th Meridian Network	Calendar Year 1965	January 1967

1. Radiation Surveillance Network February 1967

National Center for Radiological Health
U.S. Public Health Service

Surveillance of atmospheric radioactivity in the United States is conducted by the Radiation Surveillance Network (RSN) which regularly gathers samples at 74 stations distributed throughout the country (figure 1). Most of the stations are operated by State health department personnel.

Daily samples or airborne particles and precipitation are forwarded to the Radiation Surveillance Network Laboratory in Rockville, Md., for laboratory analysis. The alerting function of the network is provided by routine field estimates of the gross beta radioactivity made by the station operators prior to submission of the samples for laboratory analysis. When high air levels are reported, appropriate officials are promptly notified. Compilation of field estimates and laboratory confirmations are reported elsewhere on a monthly basis (*1*). A detailed description of the sampling and analytical procedures was presented in the November 1966 issue of *Radiological Health Data and Reports*.

Table 1 presents the monthly average gross beta radioactivity in surface air and deposition by precipitation during February 1967. Time profiles of gross beta radioactivity in air for eight RSN stations are shown in figure 2.

Airborne gross beta radioactivity decreased appreciably during February. The two samples in table 2 exceeded 1.0 pCi/m³.

Fresh fission products were identified by gamma-ray spectroscopy on 107 out of 286 samples counted.

Deposition by precipitation also decreased in February. Forty samples contained more than minimum reporting levels of gross beta radioactivity. The highest concentration was 1,900 pCi/liter collected at Barre, Vt., on February 14, and the highest total deposition for the month was 7.0 nCi/m², also at Barre, Vt.

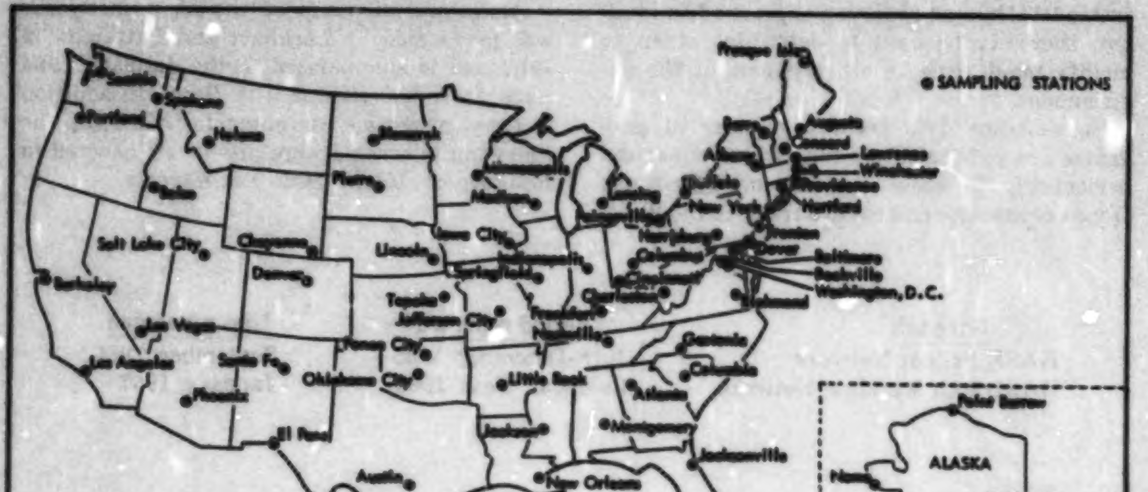

● SAMPLING STATIONS
Seattle
Spokane
Portland
Helena
Boise
Bismarck
Pierre
Minneapolis
Madison
Salt Lake City
Cheyenne
Lincoln
Iowa City
Denver
Berkeley
Springfield
Indianapolis
Topeka
Jefferson City
Las Vegas
Kansas City
Santa Fe
Los Angeles
Oklahoma City
Phoenix
Little Rock
El Paso
Jackson
Austin
New Orleans
Montgomery
Jacksonville
Miami
Presque Isle
Augusta
Concord
Lawrence
Winchester
Providence
Hartford
Albany
Buffalo
New York
Lansing
Harrisburg
Trenton
Dover
Columbus
Cincinnati
Baltimore
Rockville
Washington, D.C.
Charleston
Richmond
Frankfort
Nashville
Gastonia
Columbia
Atlanta
ALASKA
Point Barrow
Nome
Fairbanks
Anchorage
Kodiak
Juneau
Attu
St. Paul Island
Adak
Stations Not Shown
● Agana, Guam
● Honolulu, Hawaii
● San Juan, Puerto Rico
● Ancon, Canal Zone

Figure 1. Radiation Surveillance Network sampling stations

Table 1. Gross beta radioactivity in surface air and precipitation, February 1967

Station location		Number of samples		Air surveillance, gross beta radioactivity (pCi/m³)			Last profile in RHD&R	Precipitation	
		Air	Pptn	Maximum	Minimum	Average a		Total depth (mm)	Total deposition (nCi/m²)
Ala:	Montgomery	25	10	0.37	0.05	0.20	Nov 66	156	<27
Alaska:	Adak	23		.31	.05	.15	Jun 67	(b)	
	Anchorage	14	5	.46	.14	.25	Dec 66	(b)	
	Attu Island	10		.14	.08	.09	Jul 66	(b)	
	Fairbanks	7	2	.09	.05	.07	Jan 67	4	< 1
	Juneau	15	15	.13	.05	.05	Apr 67	212	<40
	Kodiak	10		.19	.07	.11	May 67	(b)	
	Nome	(c)					Sep 66	(b)	
	Pt. Barrow	10		.45	.07	.16	Aug 66	(b)	
	St. Paul Island	(c)					Oct 66	(b)	
Ariz:	Phoenix	25		.35	.13	.40	Apr 67	(b)	
Ark:	Little Rock	26	3	.46	.11	.21	Dec 66	84	<11
Calif:	Berkeley	17	1	.46	.09	.31	May 67	9	< 3
	Los Angeles	18	1	1.05	.05	.34	Sep 66	3	< 1
C.Z.:	Ancon	14		.11	.02	.06	May 67	(b)	
Colo:	Denver	25	2	.67	.14	.27	May 67	3	< 1
Conn:	Hartford	27	8	.36	.05	.19	Apr 67	35	< 7
Del:	Dover	19		.23	.07	.16	Nov 66	(b)	
D.C.:	Washington	21	5	.36	.07	.18	Aug 66	35	< 7
Fla:	Jacksonville	27	7	.42	.02	.21	Dec 66	147	<30
	Miami	27	4	.46	.04	.31	Apr 67	94	< 7
Ga:	Atlanta	26	5	.45	.06	.22	Oct 66	108	<33
Guam:	Agana	27		.25	.00	.06	Nov 66	(b)	
Hawaii:	Honolulu	27	4	.30	.01	.08	Jul 66	115	<36
Idaho:	Boise	28	6	2.05	.04	.25	Jul 66	16	< 3
Ill:	Springfield	28	6	.27	.05	.16	Aug 66	38	< 5
Ind:	Indianapolis	28	6	.34	.10	.19	Oct 66	43	< 8
Iowa:	Iowa City	28	7	.60	.06	.18	May 67	30	< 6
Kans:	Topeka	28	3	.29	.10	.18	Dec 66	1	< 1
Ky:	Frankfort	27	5	.68	.10	.30	Aug 66	35	< 7
La:	New Orleans	27	7	.68	.04	.26	Aug 66	101	<30
Maine:	Augusta	28	9	.33	.03	.18	Sep 66	106	<22
	Presque Isle	20		.35	.08	.14	May 67	(b)	
Md:	Baltimore	18	4	.33	.06	.19	Apr 67	31	< 6
	Rockville	15	3	.33	.06	.16	Jul 66	41	< 8
Mass:	Lawrence	26	6	.43	.05	.21	Nov 66	58	<12
	Winchester	16	10	.42	.07	.19	Jun 67	71	<15
Mich:	Lansing	28		.27	.08	.16	Jul 66	(b)	
Minn:	Minneapolis	16	8	.36	.07	.14	Nov 66	14	< 3
Miss:	Jackson	28	7	.36	.03	.17	Sep 66	84	<17
Mo:	Jefferson City	28	4	.35	.07	.18	Oct 66	37	< 7
Mont:	Helena	26	5	.55	.06	.23	Jun 67	16	< 3
Nebr:	Lincoln	20		.41	.03	.11	Oct 66	(b)	
Nev:	Las Vegas	28		.74	.17	.37	Jan 67	(b)	
N.H.:	Concord	19		.26	.08	.22	Aug 66	(b)	
N.J.:	Trenton	27	6	.31	.06	.16	Sep 66	14	< 3
N. Mex:	Santa Fe	27	4	.47	.10	.26	Jun 67	17	< 4
N.Y.:	Albany	18	9	.38	.11	.21	Oct 66	22	< 6
	Buffalo	27		.28	.07	.14	May 67	(b)	
	New York City	27		.37	.08	.19	Jun 67	(b)	
N.C.:	Gastonia	28	9	.37	.01	.21	May 67	70	<18
N. Dak:	Bismarck	28	7	.24	.07	.12	Aug 66	37	< 5
Ohio:	Cincinnati	12		.28	.11	.20	Nov 66	(b)	
	Columbus	26	7	.50	.13	.35	Sep 66	37	< 8
	Painesville	28	9	.32	.07	.18	Apr 67	54	<15
Okla:	Oklahoma City	27	4	.43	.06	.14	Jul 66	5	< 1
	Ponca City	27	3	.16	.04	.07	Apr 67	23	< 5
Oreg:	Portland	24	9	.31	.01	.13	Oct 66	44	< 9
Pa:	Harrisburg	28		.30	.06	.13	Oct 66	(b)	
P.R.:	San Juan	23	2	.17	.03	.09	Sep 66	69	<14
R.I.:	Providence	27	7	.35	.08	.16	Jul 66	25	< 5
S.C.:	Columbia	26	8	.31	.08	.17	Jun 67	96	<19
S. Dak:	Pierre	28		.33	.08	.12	Apr 67	(b)	
Tenn:	Nashville	28	5	.33	.07	.17	Jul 66	48	<10
Tex:	Austin	28	4	.38	.07	.18	Nov 66	30	< 6
	El Paso	25	7	.57	.14	.26	Aug 66	2	< 1
Utah:	Salt Lake City	27	1	.70	.05	.32	Sep 66	30	< 5
Vt:	Barre	27	9	.23	.07	.10	Dec 66	29	<11
Va:	Richmond	28	4	.29	.06	.16	Dec 66	22	< 7
Wash:	Seattle	25	9	.32	.00	.09	Dec 66	33	< 8
	Spokane	28	2	.35	.04	.14	Nov 66	2	< 1
W. Va:	Charleston	28	9	.41	.08	.17	Jun 67	60	<12
Wis:	Madison	27	6	.31	.04	.12	Dec 66	40	<10
Wyo.	Cheyenne	27	3	.48	.11	.22	Jan 67	10	< 3
Network summary		1,718	301	2.05	0.00	0.17		47	<10

---

a The monthly average is calculated by weighting the individual samples with length of sampling period. Values of 0.005 pCi/m³ or less are reported and used in averaging as 0.00 pCi/m³.

b No precipitation sample collected.

c No report received.

-158-

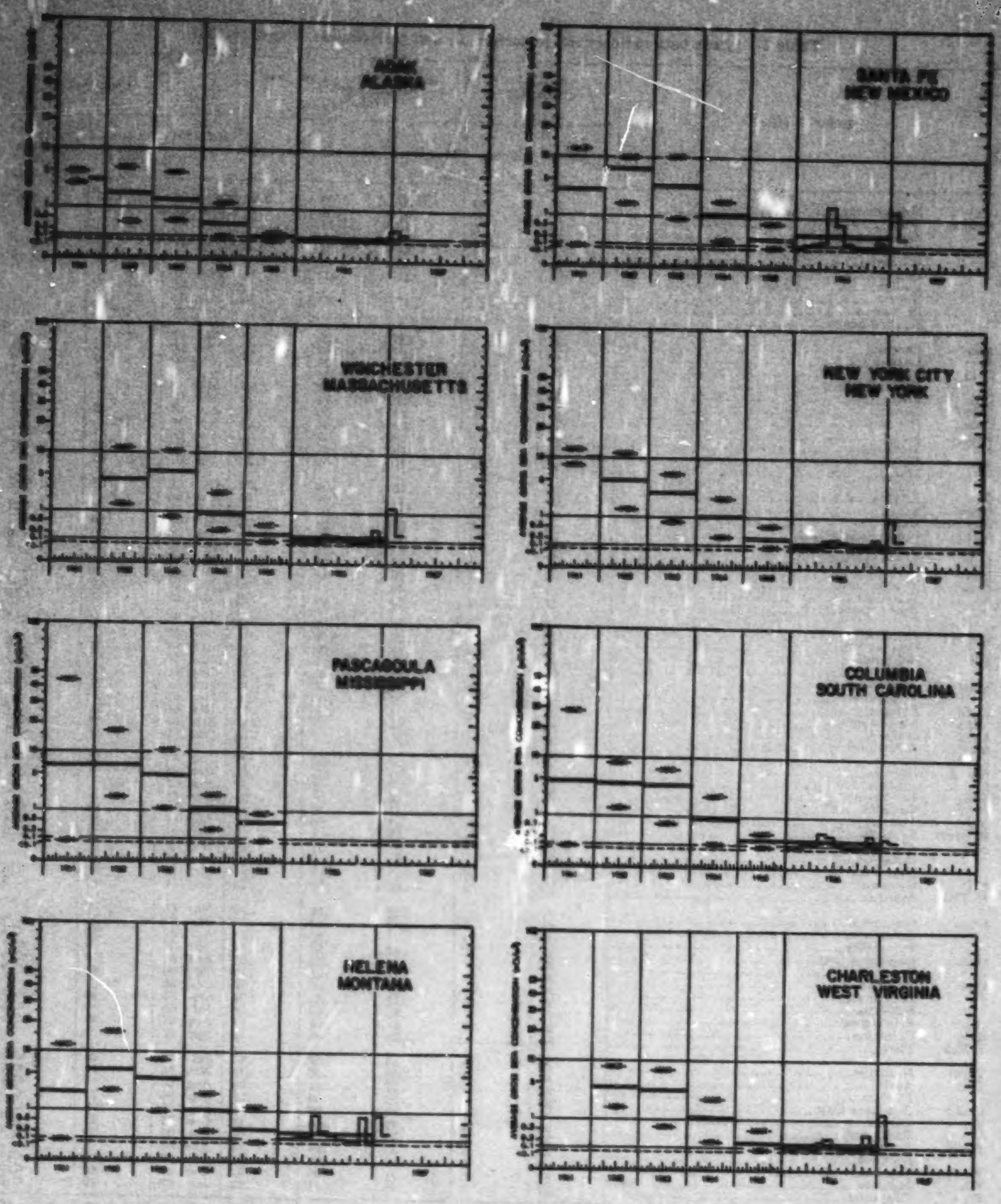


Figure 2. Monthly and yearly profiles of gross beta radioactivity in air—Radiation Surveillance Network 1961–February 1967

Table 2. RSN stations with gross beta radioactivity in particulates in excess of 1 pCi/m³

Location	Date	Beta radioactivity (pCi/m³)
Calif: Los Angeles	[illegible]	[illegible]
Idaho: Boise	[illegible]	[illegible]

2. Canadian Air and Precipitation Monitoring Program, February 1967[1]

Radiation Protection Division
Department of National Health and Welfare

The Radiation Protection Division of the Canadian Department of National Health and Welfare monitors surface air and precipitation in connection with its Radioactive Fallout Study Program. Twenty-four collection stations are located at airports (figure 3), where the sampling equipment is operated by personnel from the Meteorological Services Branch of the Department of Transport. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports of the Department of National Health and Welfare (*2–6*).

A summary of the sampling procedures and methods of analysis was presented in the November 1966 issue of *Radiological Health Data and Reports.*

Surface air and precipitation data for February 1967 are presented in table 3.

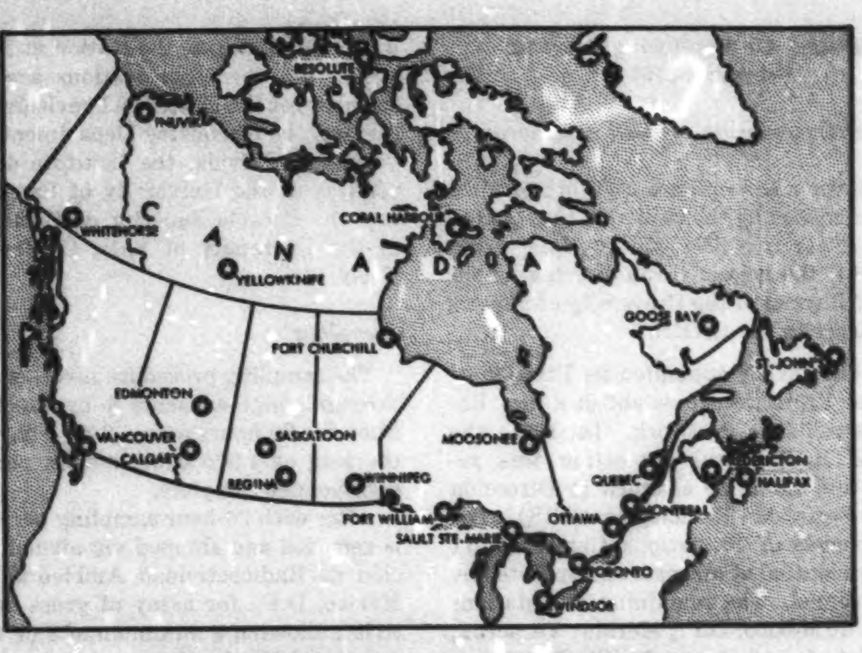

RESOLUTE
INUVIK
WHITEHORSE
C A N A D A
CORAL HARBOUR
YELLOWKNIFE
GOOSE BAY
FORT CHURCHILL
ST. JOHN'S
EDMONTON
MOOSONEE
VANCOUVER
SASKATOON
CALGARY
FREDERICTON
REGINA
WINNIPEG
QUEBEC
HALIFAX
MONTREAL
FORT WILLIAM
OTTAWA
SAULT STE. MARIE
TORONTO
WINDSOR

Figure 3. Canadian air and precipitation sampling stations

---

[1] Prepared from information and data in the March 1967 monthly report "Data from Radiation Protection Program," Canadian Department of National Health and Welfare, Ottawa, Canada.

Table 2. Canadian gross beta radioactivity in surface air and precipitation, February 1967

Station	Number of samples	Air surveillance radioactivity (pCi/m³)			Precipitation measurements	
		Maximum	Minimum	Average	Average concentrations (pCi/liter)	Total deposition (nCi/m²)
Calgary	28	0.8	0.1	0.2	96	1.0
Coral Harbour	27	.4	.0	.2	(a)	1.5
Edmonton	28	.4	.1	.2	71	1.0
Ft. Churchill	28	.4	.0	.2	132	1.1
Ft. William	28	.5	.1	.1	18	.3
Fredericton	28	.3	.1	.2	14	1.8
Goose Bay	27	.3	.0	.2	78	4.1
Halifax	27	.4	.1	.3	15	1.9
Inuvik	28	.3	.1	.2	88	.8
Montreal	28	.4	.1	.2	NS	NS
Moosonee	27	.3	.1	.2	20	.6
Ottawa	28	.4	.1	.2	19	1.1
Quebec	28	.3	.1	.2	34	3.9
Regina	28	.3	.1	.2	69	.8
Resolute	28	.5	.1	.2	(a)	.1
St. John's Nfld	28	.3	.0	.1	NS	NS
Saskatoon	28	.3	.1	.2	68	.7
Sault Ste. Marie	27	.5	.0	.2	18	1.2
Toronto	28	.4	.1	.2	47	2.7
Vancouver	28	.4	.0	.1	80	6.6
Whitehorse	28	.3	.0	.2	35	1.6
Windsor	28	.6	.1	.2	50	1.9
Winnipeg	28	.4	.1	.2	78	.7
Yellowknife	28	.4	.0	.2	42	.6
Network summary	------	0.4	0.1	0.2	53	1.5

[a] Trace precipitation
NS, no sample

3. Mexican Air Monitoring Program February 1967

National Commission of Nuclear Energy

The Radiation Surveillance Network of Mexico was established by the Comisión Nacional de Energía Nuclear (CNEN), México, D.F. From 1952 to 1961, the network was directed by the Institute of Physics of the University of Mexico, under contract to the CNEN.

In 1961, the CNEN appointed its Division of Radiological Protection to establish a new Radiation Surveillance Network. In 1966, the Division of Radiological Protection was restructured and its name changed to Dirección General de Seguridad Radiológica (DRS). The network consists of 16 stations (figure 4), 11 of which are located at airports and operated by airline personnel. The remaining five stations are located at México, D.F.; Mérida; Veracruz; San Luis Potosí; and Ensenada. Staff members of the DRS operate the station at México, D.F., while the other four stations are manned by members of the Centro de Previsión del Galfo de México, the Chemistry Department of the University of Mérida, the Institute de Zonas Desérticas of the University of San Luis Potosí, and the Escuela Superior de Ciencias Marinas of the University of Baja, California, respectively.

Sampling

The sampling procedure involves drawing air through a high-efficiency 6- by 9-inch glass-fiber filter for 20 hours a day, 3 or 4 days a week at the rate of 1,000 cubic meters per day using high-volume samplers.

After each 20-hour sampling period, the filter is removed and shipped via airmail to the Sección de Radioactividad Ambiental, CNEN, in México, D.F., for assay of gross beta radioactivity allowing a minimum of 3 or 4 days after collection for the decay of radon and thoron.

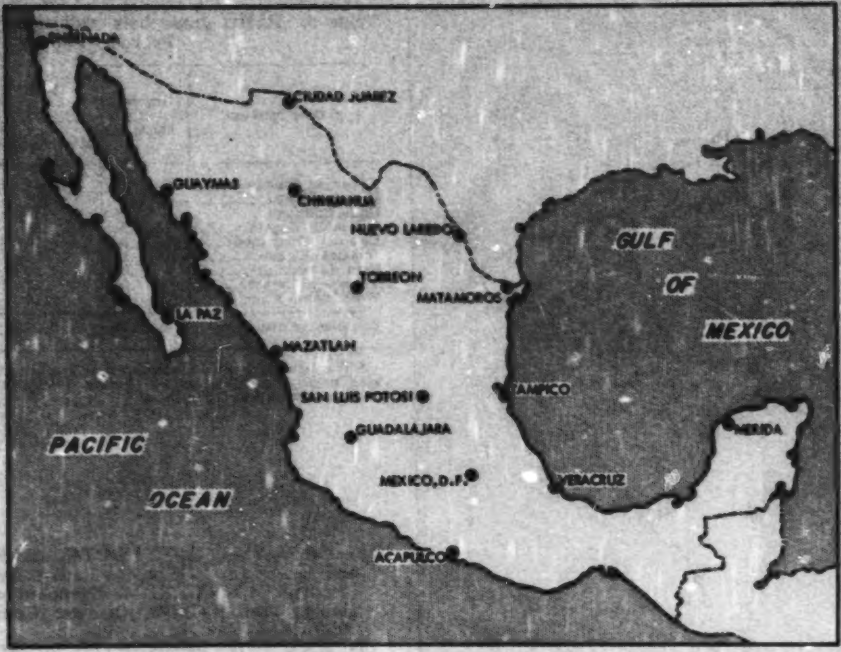


Figure 4. Mexican air sampling locations

The data are not extrapolated to the time of collection. Statistically, it has been found that a minimum of eight samples per month were needed to get a reliable average activity at each station (7).

The maximum, minimum, and average gross beta radioactivity in surface air during February 1967 are presented in table 4.

Table 4. Mexican gross beta radioactivity of airborne particulates, February 1967

Station	Number of samples	Gross beta radioactivity (pCi/m³)		
		Maximum	Minimum	Average
Acapulco	18	0.3	0.1	0.2
Chihuahua	7	.6	.1	.2
Ciudad Juárez	10	.4	< .1	.3
Ensenada	9	.6	.1	.3
Guadalajara	NS	----	----	----
Guaymas	NS	----	----	----
La Paz	3	.9	.2	----
Matamoros	NS	----	----	----
Mazatlán	15	.6	.1	.3
Mérida	10	.4	.1	.2
México, D.F.	12	.3	< .1	.1
Nuevo Laredo	1	----	----	----
San Luis Potosí	NS	----	----	----
Tampico	NS	----	----	----
Torreón	22	.5	.1	.2
Veracruz	3	.1	< .1	----

NS, no sample collected, station temporarily shutdown.

4. Pan American Air Sampling Program February 1967

Pan American Health Organization and *U.S. Public Health Service*

Gross beta radioactivity in air is monitored by countries in the Americas under the auspices of the collaborative program developed by the Pan American Health Organization (PAHO) and the U.S. Public Health Service (PHS) to assist PAHO-member countries in developing radiological health programs. The sampling equipment and analytical services are provided by the National Center for Radiological Health, PHS, and are identical with those employed for the Radiation Surveillance Network. The air sampling station positions are shown in figure 5.

The February 1967 air monitoring results from the participating countries are given in table 5. The most active sample was collected at Caracas, Venezuela on February 17th, and measured 0.27 pCi/m³ when counted on February 24, 1967. No fresh fission products were identified in PAHO air samples during February.

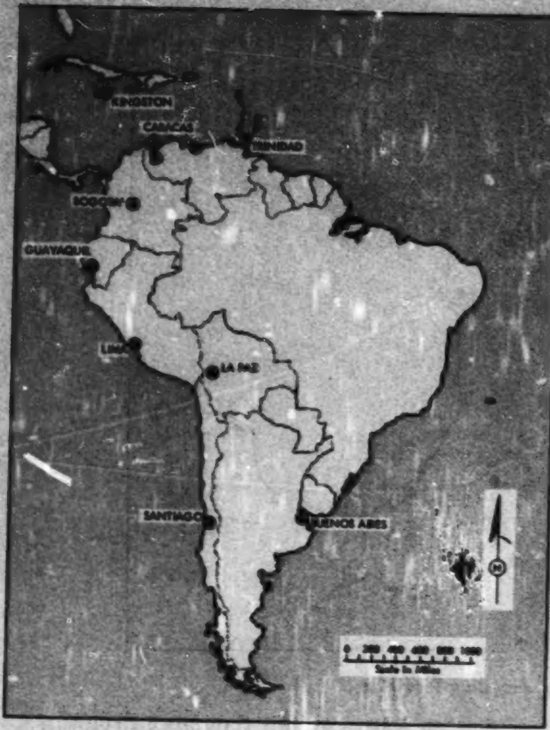


Figure 5. Pan American Air Sampling Program stations

Table 5. PAHO gross beta radioactivity in surface air February 1967

Station location	Number of samples	Gross beta radioactivity (pCi/m³)		
		Maximum	Minimum	Average ᵃ
Argentina, Buenos Aires	17	0.18	0.03	0.09
Bolivia, La Paz	14	.06	.01	.02
Chile, Santiago	28	.14	.03	.08
Colombia, Bogota	21	.08	.01	.04
Ecuador, Guayaquil	21	.04	.00	.02
Jamaica, Kingston	16	.14	.03	.08
Peru, Lima	25	.09	.04	.05
Venezuela, Caracas	14	.27	.02	.08
West Indies, Trinidad	16	.10	.03	.06
Pan American summary	172	0.27	0.00	0.06

ᵃ The monthly average is calculated by weighting the individual samples with length of sampling period. Values of 0.005 or less are reported and used in averaging as 0.00 pCi/m³.

REFERENCES

(1) RADIATION SURVEILLANCE NETWORK. Monthly tabulation of findings. National Center for Radiological Health, Public Health Service, Rockville, Md. 20852 (Distribution by official request).

(2) BIRD, P. M., A. H. BOOTH, and P. G. MAR. Annual report of 1959 on the Radioactive Fallout Study Program, CNHW-RP-3. Department of National Health and Welfare, Ottawa, Canada (May 1960).

(3) BIRD, P. M., A. H. BOOTH, and P. G. MAR. Annual report for 1960 on the Radioactive Fallout Study Program, CNHW-RP-4. Department of National Health and Welfare, Ottawa, Canada (December 1961).

(4) MAR, P. G. Annual report for 1961 on the Radioactive Fallout Study Program, CNHW-RP-5. Department of National Health and Welfare, Ottawa, Canada (December 1962).

(5) BEALE, J., and J. GORDON. The operation of the Radiation Protection Division Air Monitoring Program, RPD-11. Department of National Health and Welfare, Ottawa, Canada (July 1962).

(6) BOOTH, A. H. The calculation of permissible levels of fallout in air and water and their use in assessing the significance of 1961 levels in Canada, RPD-21. Department of National Health and Welfare, Ottawa, Canada (August 1962).

(7) VASQUEZ, M., and R. M. DE NULMAN. Estudios sobre la radioactividad ambiental en la Republica Mexicana, 1963-1965. Comisión Nacional de Energía Nuclear, Dirección General de Seguridad Radiológica (en prensa 1966).

SECTION IV. OTHER DATA

This section presents results from routine sampling of biological materials and other media not reported in the previous sections. Included are such data as those obtained from human bone sampling, bovine thyroid sampling, and environmental monitoring reports.

Environmental Levels of Radioactivity at Atomic Energy Commission Installations

The U.S. Atomic Energy Commission receives from its contractors semiannual reports on the environmental levels of radioactivity in the vicinity of major Commission installations. The reports include data from routine monitoring programs where operations are of such a nature that plant environmental surveys are required.

Releases of radioactivity materials from AEC installations are governed by radiation protection standards set forth by AEC's Division of Operational Safety in directives published in the "AEC Manual."[1]

Summaries of the environmental radioactivity data follow for the Brookhaven National Laboratory and the Lawrence Radiation Laboratory.

---

[1] Title 10, Code of Federal Regulations, Part 20, "Standards for Protection Against Radiation," contains essentially the standards published in Chapter 0524 of the AEC Manual.

1. Brookhaven National Laboratory July–December and annual summary 1966[2]

Associated Universities, Inc.
Upton, New York

The Brookhaven National Laboratory (BNL) operations may affect the environmental levels of radiation in three ways: 1) by discharge of coolant air from the graphite research reactor, 2) by radiation from an ecology forest gamma-ray source, and 3) by the discharge of low-level radioactive liquid wastes into a small stream that forms one of the headwaters of the Peconic River (figure 1).

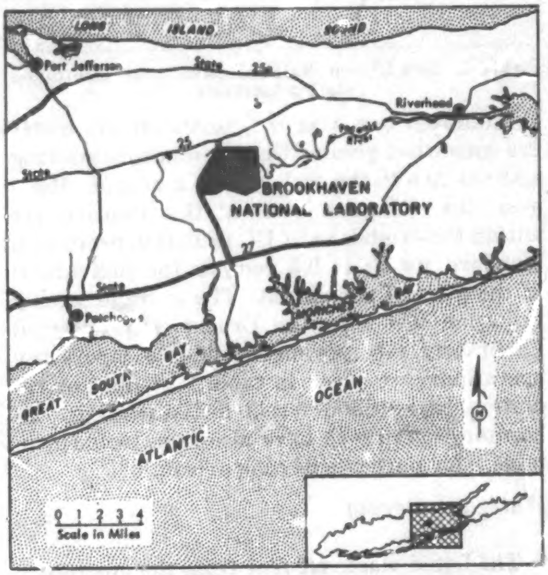


Figure 1. Brookhaven National Laboratory and surrounding area

---

[2] Summarized from "Effects of Brookhaven National Laboratory on Environmental Levels of Radioactivity during the Second Half of 1966," Associated Universities, Inc., Upton, N.Y.

-164-

Area monitoring

The radioactivity in the discharge coolant air is almost entirely due to argon–41, a beta-gamma emitter. Monitoring for argon–41 is performed by continuously measuring the gamma-ray exposure rate in milliroentgens per week (mR/wk), rather than the concentration in air, at four stations located along the site perimeter (figure 2). These same stations monitor radioactivity resulting from a 10,000 curie cesium–137 gamma-ray source, situated in an ecology forest, about 800-meters equidistant from the north and east boundaries of the BNL.

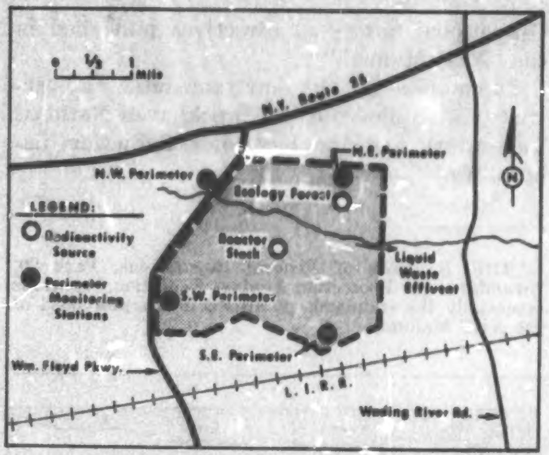


Figure 2. Brookhaven National Laboratory monitoring station locations

Radiation levels at the northeast perimeter are somewhat greater than at other monitoring stations due to the ecology forest source. However, the radiation levels at this location are within the established AEC radiation protection standard which is 0.5 rem/yr for individuals in the general population. The average weekly radiation levels at the Brookhaven National Laboratory site perimeter, due to laboratory operations, are given in table 1. Values of radiation background levels undisturbed by laboratory operations have also been included in table 1 for purposes of comparison.

Water monitoring

The liquid waste effluent from the laboratory sewage processing plant is monitored continuously at the point where the stream leaves the BNL site. The average concentration and total amount of gross beta radioactivity in the liquid waste effluent, at the site boundary, are shown in table 2 for July to December and calendar year 1966.

Table 1. External gamma radioactivity at BNL site perimeter July-December and calendar year 1966

Period	Average exposure rates (mR/wk)			
	Northwest perimeter	Southwest perimeter	Southeast perimeter	Northeast perimeter
Second half 1966	0.13	0.23	0.19	2.06
July	.08	.10	.19	2.06
August	.10	.17	.23	3.04
September	.21	.57	.14	2.50
October	.14	.14	.57	2.08
November	.06	.08	.02	2.00
December	.17	.34	.07	1.76
First half 1966	.18	.20	.46	2.33
Calendar year 1966	.16	.22	.33	2.40
Undisturbed background, calendar year 1966	1.95	1.78	1.92	1.98

Analysis of composite samples of the effluent has shown that, on the average, no more than 20 percent of the radioactivity consists of strontium–90 and that no appreciable amounts of radioactive iodine or radium and other bone-seeking radionuclides are present. Under these conditions, the applicable AEC radiation protection standard for discharge of liquid waste to uncontrolled areas would be 3,000 pCi/liter.

Table 2. Gross beta radioactivity in liquid waste effluent at BNL site boundary, July-December and calendar year 1966

Period	Average radioactivity (pCi/liter)	Total radioactivity discharged (mCi)
Second half 1966	26	14.8
July	41	3.8
August	28	3.3
September	22	2.0
October	21	2.3
November	23	1.8
December	28	1.6
First half 1966	38	20.6
Calendar year 1966	32	35.4

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
July–December 1965	June 1966
January–June 1966	December 1966

2. Lawrence Radiation Laboratory January–June 1966[a]

University of California
Berkeley, California

Berkeley site

The Berkeley site of the Lawrence Radiation Laboratory (LRL) is located to the east of the University of California campus (figure 3). Winds are generally westerly; annual rainfall is 23 inches, most of which usually falls during the period from November through April. Technical facilities include a 6.3 BeV proton accelerator (Bevatron), a 700-MeV cyclotron, a 10-MeV linear accelerator, an 88-inch cyclotron, and associated chemistry and physics laboratories.

The environmental monitoring program includes sampling for radionuclides in the atmosphere, surface and ground waters, sewage, rain, and dry depositions.

Three types of atmospheric samples are taken: laboratory exhaust duct samples, local area samples and perimeter samples. One hundred eleven exhaust air ducts with potential for releasing radioactive contaminants are sampled continuously at a flow rate of 1 liter per minute. The one-inch-diameter filters are changed weekly and counted for beta radioactivity by an end-window Geiger-Mueller tube and for alpha radioactivity by a thin-window proportional counter. Continuous local area and perimeter air samples are taken at scattered locations on the laboratory site and at the property line, respectively. The samples are obtained on 4- by 9-inch HV–70 filter papers at 4 cubic feet per minute. The filters are collected weekly and counted for alpha radioactivity by a thin-window proportional counter and for beta radioactivity by a 30 mg/cm²-window Geiger-Mueller tube. The levels of radioactivity observed in each type of sample are presented in table 3.

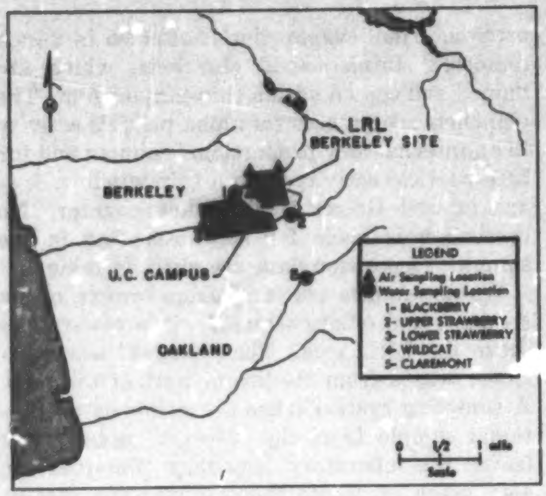


Figure 3. Environmental sampling locations at the Berkeley site

Rain and dry deposition samples are collected monthly in 18-inch diameter cylindrical vessels lined with polyethylene bags at local area and perimeter sites. Precipitation samples are concentrated by evaporation. Dry samples are removed from the collection vessel with a dilute nitric acid rinse and then concentrated by evap-

Table 3. Atmospheric monitoring, LRL Berkeley site, January-June 1966

Sampling locations (number of locations)	Number of samples	Concentration[a] (pCi/m³)			
		Alpha radioactivity		Beta radioactivity	
		Average	Maximum	Average	Maximum
Exhaust ducts (111)	4,327	<0.10	(b)	<2.3	(b)
Local area (10)	230	< .005	<0.005	<0.15	0.55
Perimeter (4)	100	< .005	.009	< .15	.47

[a] Limits of detectability for individual samples (pCi/m³):
Exhaust ducts .... 0.10 alpha 2.3 beta
Local area and perimeter ...... 0.005 alpha 0.15 beta

[b] No reported data.

---

[a] Summarized from "Results of Environmental Radioactivity Sampling Program, January–June 1966," Lawrence Radiation Laboratory, Livermore and Berkeley, Calif.

ation. Final evaporation is effected in 2-inch diameter stainless-steel planchets, which are flamed and coated with a thin lacquer film. The planchets are counted for alpha-particle activity in an internal-flow proportional counter and for beta-particle activity with a thin-window, low-background Geiger-Mueller flow counter. No correction is made for self-absorption in the sample. Deposition data are given in table 4.

Water samples are taken from sewers, onsite streams, and offsite streams. Two sewer lines serve the LRL area. The "Hearst" sewer receives waste from the larger part of the area. A sampling system takes a continuous proportional sample from the "Hearst" sewer as it leaves the laboratory boundary. Samples are also taken of waste feeding into the Hearst sewer from buildings 70, 70A, and 71. The "Strawberry" sewer receives waste from the southeast part of the laboratory site. A monitoring station takes a continuous proportional sample from this sewer. Continuous samples are also taken from the acid waste systems in building 74, which is the most likely contributor of radioactivity to the "Strawberry" sewer line. The concentrations of radioactive wastes in sewage, shown in table 5, are either those observed directly in samples from the sewer line or those calculated from samples taken from contributing waste streams, whichever was the higher value. Strawberry and Blackberry Creeks comprise the laboratory's storm drainage. These are sampled weekly at three locations. Two other nearby offsite streams are also sampled weekly. All water samples are handled in the same manner as rain samples. The results from the water sampling program are presented in table 5.

Table 4. Total deposition, LRL Berkeley site, January-June 1966

Sampling locations (number of locations)	Number of samples	Deposition (nCi/m²)			
		Alpha radioactivity		Beta radioactivity	
		Average	Maximum[a]	Average	Maximum[a]
Local area (10)	58	0.02	0.10	0.81	2.96
Perimeter (4)	24	.03	.07	.81	2.20

[a] Maximum deposition at a single location for the 6-month period.

Table 5. Water monitoring, LRL Berkeley site, January-June 1966

Type and source of sample	Number of samples	Concentration (pCi/liter)			
		Alpha radioactivity		Beta radioactivity	
		Average	Maximum	Average	Maximum
Sewage:					
Hearst sewer	25	1.33	23.6	40.1	57.3
Strawberry sewer	26	0.45	3.6	40.0	396.4
Tap water	26	0.02	0.4	3.0	7.9
Surface water:					
Onsite streams	96	1.17	10.7	7.7	73.7
Offsite streams	50	0.30	2.6	3.1	26.0

Livermore site

The Livermore site of LRL (figure 4) is located about 50 miles southeast of San Francisco, Calif. Annual precipitation in the Livermore Valley is about 14 inches; prevailing winds are from the west with frequent nocturnal inversions. Technical facilities include a small cyclotron, a 2-megawatt swimming pool reactor, and physics and chemistry programs associated with a weapons development program.

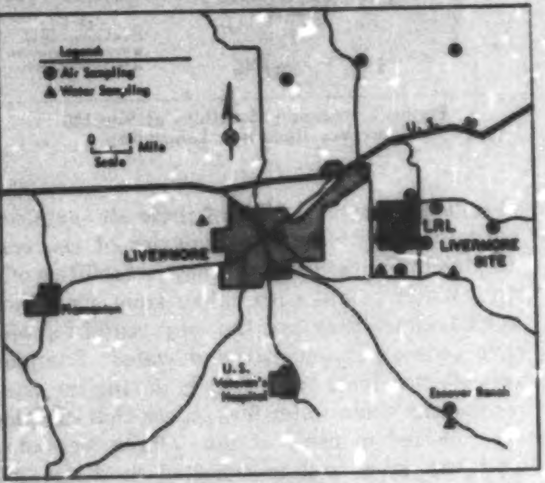


Figure 4. Environmental sampling locations at the Livermore site

An environmental sampling program is maintained to provide information regarding the effectiveness of control measures and to determine whether any radiological changes in the environment are the result of laboratory operations. The sampling program includes air particulates, soil, domestic water, sewer effluent, and sewage plant products, and since January of this year, milk. The milk samples are obtained from two dairies in the Livermore Valley and one in a neighboring valley, which is used as a check. Air samples are collected to ascertain that control efforts are restricting the release of radioactivity from the laboratory to levels which do not exceed the permissible levels for the neighborhood around an atomic energy facility. The water samples are collected to monitor radioactivity in an underground water supply which provides most of the domestic water for the cities of Livermore and Pleasanton, and is the sole supply for ranches in the Livermore and Amador Valleys.

Air samples are collected continuously at 15 sites within 5 miles of the laboratory. Samples are collected at a rate of 4 cfm on 100-square centimeter HV-70 filter papers, which are changed after every 7 days of operation. A minimum decay period of 96 hours is observed before the samples are counted to eliminate the effect of natural radon and thoron daughters. All environmental air samples are counted in an automated system which utilizes gas-flow proportional detectors for both alpha and beta-particle activity measurements. Alpha-particle activity in 401 air samples collected from 15 sampling locations averaged 0.0010 pCi/m^3, while beta-particle activity averaged 0.060 pCi/m^3. The applicable AEC radiation protection standards are 0.040 pCi/m^3 for alpha-particle emitters and 1 pCi/m^3 for beta-particle emitters.

The measurement of low level "background" radiation during this period was accomplished with fluoroglass dosimeters located at nine points on the site perimeter and at two nearby ranches. The dosimeters, which have a detection limit of 50 mR, were measured after 6-months of exposure. No dosimeter indicated a detectable amount of external radiation for the period. The average dose rate at the laboratory perimeter, based upon these measurements, was less than 0.01 mR/hr.

Domestic water samples are collected monthly from nine nearby sources. No water sample showed alpha radioactivity above the limit of sensitivity (5.0 pCi/liter) for the automatic gas-flow proportional detection system. The beta radioactivity ranged from less than the limit of sensitivity (1.8 pCi/liter) to 13 pCi/liter. The average alpha and beta radioactivity in water samples was less than their respective AEC radiation protection standards of 10 and 100 pCi/liter.

Samples are collected every Monday, Wednesday, and Friday, at the sewer line leaving the southwest project boundary, where it connects with the Livermore domestic sewerage system. Grab samples are collected monthly at the Livermore Sewage Disposal Plant to assure that the liquid effluent from the laboratory is

-168-

not creating abnormal radioactivity concentrations either in the oxidation ponds (which overflow into a natural waterway) or in the dried sludge (which is used as an agricultural soil conditioner). Radioactivity levels in the raw sewage, oxidation ponds, and dried sludge are summarized in table 6.

Table 6. Environmental sampling, LRL Livermore site January-June 1966

Type of sample (concentration units)	Average alpha radioactivity	Average beta radioactivity
Raw sewage (pCi/liter)	6	77
Oxidation ponds (pCi/liter)	7	78
Dried sludge (pCi/g)	42	13

Samples of top layer soil are collected quarterly at the 19 sampling stations surrounding the Livermore site. The alpha-particle activity fluctuated from less than the limit of sensitivity (1.5 pCi/g) to 9 pCi/g. The beta-particle activity fluctuated from less than the limit of sensitivity (3.5 pCi/g) to 23 pCi/g. The average alpha radioactivity was 2.8 pCi/g and the average beta radioactivity was 7.0 pCi/g. The concentrations detected are within the normal range for soil in the Livermore Valley.

Average radioactivity levels in monthly milk samples amounted to 14 pCi/liter of cesium-137 and 6 pCi/liter of cerium-141-144, for the two Livermore dairies. These levels closely correspond to those for a dairy in a neighboring valley about 25 miles from Livermore. The June milk samples showed slight increases due to the Chinese nuclear test in May.

Site 300

Site 300 (figure 5) is located in a very sparsely populated ranching area about 17 miles southeast of the Lawrence Radiation Laboratory at Livermore. Air and water samples are taken to determine whether operations at Site 300 are changing the normal radioactivity levels in the vicinity. The eight air samplers at Site 300 are operated at about 50 cfm on a continuous basis with the filter papers being changed on regular schedule. Most of these air samplers are located within the boundaries of the test site due to unavailability of power facilities offsite. Water samples are taken from six onsite wells because they are the only readily accessible sources of underground water. Samples are collected from streams only during the winter months when water flow exists. Soil samples are collected monthly at nine offsite locations. Only top layer soil is collected to determine fallout concentrations. All air, water, and soil samples are processed at the laboratory in Livermore. The average radioactivity levels in samples collected are summarized in table 7.

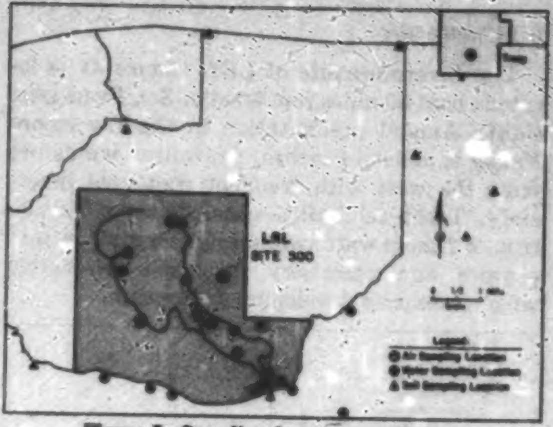


Figure 5. Sampling locations at Site 300 Lawrence Radiation Laboratory

Table 7. Environmental sampling, LRL Site 300 January-June 1966

Type of sample (concentration units)	Average alpha radioactivity	Average beta radioactivity
Air (pCi/m³)	0.001	0.058
Water (pCi/liter)	<5.0	4.4
Soil (pCi/g)	7	7

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
January-June 1965	May 1966
July-December 1965	November 1966

-169-

SECTION V. TECHNICAL NOTES

Full Scale Strontium-90 Removal System for Fluid Milk

National Center for Radiological Health
Public Health Service

Recently, it was reported (*1–2*) that 5 years of research in the laboratory and pilot plant have culminated in the successful design and operation of a full-scale commercial system capable of processing 100,000 lbs. of fluid whole milk per 8-hour day for removal of strontium-90. An extensive description of the system will be published shortly (*3*). The automated plant is constructed of stainless steel and other approved dairy industry materials meeting sanitary requirements. The full-scale process employs the fixed-bed ion-exchange principle and is based on results from a combined effort of the U.S. Department of Health, Education, and Welfare, Public Health Service, the U.S. Department of Agriculture, Agriculture Research Service, and the U.S. Atomic Energy Commission, at a pilot plant in the Agricultural Research Center, Beltsville, Md., and laboratory scale research performed at the Robert A. Taft Sanitary Engineering Center in Cincinnati, Ohio. The process involves acidification of raw milk to pH 5.35, passage through a fixed resin bed and readjustment of the milk to pH 6.60. The design, fabrication, operation, and evaluation of the full-scale process was performed under a government contract with the Producers Creamery Company of Springfield, Mo.

Several experimental runs were made using the commercial scale equipment during the period May 1964 through February 1965. The pertinent data for these tests are given in table 1. Nine test runs of 100,000 lbs. each (the February 25, 1965 run consisted of two 100,000 lb. runs) have demonstrated that an average of 92.1 percent of the strontium-90 can be removed from fluid milk. No unusual processing

Table 1. Results of commercial scale treatment of fluid milk for removal of strontium-90 by fixed-bed ion exchange

Date	Type of milk processed	Total weight of milk (lb)	Elapsed time (hr)	Average rate of flow (lb/hr)	Concentration of strontium-90 (pCi/liter)		Removal efficiency (percent)
					Raw milk	Processed milk	
5/22/64	Skim	99,340	8.08	12,400	42.3	2.9	93.1
6/24/64	Whole	103,880	12.17	8,535	36.0	1.1	96.9
8/20/64	Skim	103,540	8.82	11,820	32.9	1.8	94.5
9/2/64	Skim	104,280	8.55	12,650	43.7	2.4	94.5
9/16/64	Whole	99,840	8.75	14,265	31.0	2.1	93.2
10/14/64	Whole	103,000	11.08	12,000	25.6	2.7	89.5
2/21/65	Whole	104,900	13.22	11,685	31.7	4.4	86.1
2/25/65	Whole	202,160	15.13	13,350	32.6	3.7	88.7

problems were encountered during these runs.

Flavor scores for six of these runs, comparing control milk and treated milk are given in table 2. At a seminar conducted on February 25, 1965, milk processed on February 21 was taste-tested for acceptability of the treated product from a flavor point of view, using health, agriculture, and milk industry representatives as the taste panel. Of the 54 panelists, 9 persons could detect no difference between the treated and commercially-marketed milk, 19 persons preferred the treated milk, and 26 persons preferred the market milk.

Table 2. Average taste panel scores for whole milk[a] (samples 3 days old)

Date	Control sample	Experimental sample
8/24/64	37.4	36.8
9/16/64	36.4	37.4
10/14/64	36.6	37.8
2/21/65	37.0	36.9
2/25/65 (first run)	36.9	35.4
2/25/65 (second run)	37.1	35.2

[a] American Dairy Science standard flavor test; perfect score is 40; acceptable score for pasteurized commercial market milk is 35.

The commercial scale process was shown to be a technically acceptable method of safeguarding the milk consumer against intake of hazardous quantities of strontium-90. Its feasibility for use by the milk industry in the event of an emergency has been demonstrated. The staff of most milk processing plants are capable of properly operating the equipment following several hours of technical training. Currently, an economic evaluation of the process is underway. However, prior to the installation of the equipment for commercial use, additional evaluation and clearance of the equipment may be necessary.

REFERENCES

(*1*) FOOKS, J. H., J. G. TERRILL, JR., B. H. HEINEMANN, E. J. BALDI, and H. E. WALTER. Evaluation of the full-scale strontium removal system for fluid milk. Health Physics 13:279–286 (March 1967).

(*2*) BALES, R. E. and J. L. S. HICKEY. Commercial processing of milk for concurrent removal of cationic and anionic radionuclides. Proceedings of a seminar July 12–15, 1966, on radioisotopes and radiation in dairy science and technology, IAEA (November 1966).

(*3*) PROCEEDINGS OF A SEMINAR, LEBANON, MO., FEBRUARY 1965. Full-scale system for removal of radiostrontium from milk. A cooperative research investigation supported jointly by the USDHEW, DRH, and USDA, Agricultural Research Service, Eastern Utilization, Research and Development (In press).

Reported Nuclear Detonations, May 1967

During May 1967 the U.S. Atomic Energy Commission announced four underground nuclear tests conducted at its Nevada Test Site. The tests of May 10 and May 26 were low-intermediate yield (20 to 200 kilotons TNT equivalent) and the tests of May 20 and 23 were intermediate yield (200 kilotons to 1 megaton TNT equivalent).

SYNOPSES

Synopses of reports, incorporating a list of key words, are furnished below in reference card format for the convenience of readers who may wish to clip them for their files.

FALLOUT FROM THE THIRD CHINESE NUCLEAR TEST—MAY 9, 1966. *R. D. Grundy* and *D. R. Snavely. Radiological Health Data and Reports, Vol. 8, June 1967*, pp. 301–316.

Fresh fission product debris was detected in the United States in selected environmental media following the third Chinese atmospheric nuclear detonation of May 9, 1966. Peak concentrations in air, precipitation deposition, bovine thyroids, and milk, occurred in the Central and Southern States. Levels of iodine-131 in milk as observed by 4 State sampling programs and 18 Public Health Pasteurized Milk Network stations provides the basis for calculating iodin-131 pasture weathering half-time of 4 to 58 days. A peak iodine-131 milk concentration of 920 pCi/liter was observed in Arkansas on May 21, 1966. The resultant cumulative iodine-131 intake at this location based upon an assumed daily milk consumption of 1 liter, was calculated to correspond to 1.7 percent of the Radiation Protective Action Guide as established by the Federal Radiation Council.

KEY WORDS: air, beta radioactivity, bovine thyroid network, fallout, iodine-131, mainland China, milk, nuclear test, pasteurized milk network, pasture half-time, precipitation.